DOCUMENT RESUME

ED 460 707 JC 990 242

AUTHOR	Mahoney, James R., Ed.
TITLE	Improving Science, Mathematics, Engineering, and Technology Instruction: Strategies for the Community College.
INSTITUTION	American Association of Community Colleges, Washington, DC.
SPONS AGENCY	National Science Foundation, Arlington, VA.
ISBN	ISBN-0-87117-301-8
PUB DATE	1996-00-00
NOTE	123p.; Published by the Community College Press, a division of the AACC. Papers presented at the American Association of Community Colleges Roundtable (Washington, DC, June 7-9, 1996).
AVAILABLE FROM	American Association of Community Colleges, One Dupont Circle, N.W., Suite 410, Washington, DC 20036-1176. Tel: 202-728-0200; Fax: 202-833-2467; Web site: http://www.aace.nche.edu.
PUB TYPE	Collected Works - General (020)
EDRS PRICE	EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Access to Education; *Community Colleges; *Engineering Education; Institutional Cooperation; *Mathematics Instruction; *School Business Relationship; School Community Relationship; *Science Instruction; *Technology Education; Two Year Colleges
IDENTIFIERS	American Association of Community Colleges

ABSTRACT

This report presents the results of a June 1996 conference held in Washington, DC to discuss the condition of science, mathematics, engineering and technology education (SMET). The meeting was conducted by the American Association of Community Colleges through a grant from the National Science Foundation. The goals of the meeting were to: (1) establish general principles to build upon and guide improvements in these study areas; and (2) compose specific recommendations for stakeholders in SMET education. General guidelines were proposed in the following seven areas: (1) Relevance-- MET skills should be taught to all students at the earliest stages of education; (2) Access--there should be equal access for all students to SMET programs; (3) Benchmarks--learning and performance benchmarks should be established in the learning process; (4) Instruction-instructional strategies must be learner-centered; (5) Partnerships-educational institutions and community groups should work together; (6) Funding--new approaches to funding must be developed; and (7) Global Dimensions-the quality of our educational system should be measured against that of other countries. The report also offers recommendations to nine stakeholders in SMET education: community colleges, students, faculty, academic support personnel, academic administrators, presidents, college trustees, four-year postsecondary institutions, and government. Appended are lists of resources and occupational skills standards projects. (VF)

Reproductions supplied by EDRS are the best that can be made
from the original document.

ED 460 707

Strategies for the Community College

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

D. Carey

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

2 2B

JC 990 242

FUNDED BY THE NATIONAL SCIENCE FOUNDATION

BEST COPY AVAILABLE

James R. Mahoney, Editor

Arnold Madison Kee and Ada Mara Phillips,
Research and Technical Assistance

Pamela Humbert, Publication Design

FUNDED BY THE NATIONAL SCIENCE FOUNDATION

COMMUNITY COLLEGE PRESS

Funded by the National Science Foundation

Published in 1996 by the Community College Press,
a division of the

AMERICAN ASSOCIATION OF COMMUNITY COLLEGES

One Dupont Circle, NW, Suite 410
Washington, DC 20036-1176

Telephone: 202/728-0200
Fax: 202/833-2467
http://www.aacc.nche.edu

Printed in the U.S.A.

ISBN: 0-87117-301-8

TABLE OF CONTENTS III
PREFACES V
EXECUTIVE SUMMARY IX
PREAMBLE XIII
PART ONE: GUIDING PRINCIPLES 1
Relevance 1
Access 2
Earned Science & Engineering Associate Degrees by Ethnicity 3
Earned Science & Engineering Associate Degrees by Gender 4
Benchmarks 5
Instruction 7
Average Number of Math & Science Classes Completed by High School Students 13
Partnerships 14
NSF Support for Community Colleges Including ATE Monies 17
Funding 20
Computer Usage at Home or School 21
Computer Usage at Home Only 22
Global Dimensions 23
PART TWO: RECOMMENDATIONS TO STAKEHOLDERS 25
Community Colleges 25
Students 26
Faculty 26
Academic Support Personnel 28
Academic Administrators 28
Presidents/Chancellors 29
College Boards/Trustees 30
Other Educational Institutions 31
Business 32
Organized Labor 34
Community Organizations 35

TABLE OF CONTENTS

Parents 35

Foundations 35

Government 36

Office of the President 37

Congress 38

Education and Professional Boards and Societies 38

BACKGROUND PAPERS 41

What Mathematical Competencies Do Employers Want and How to Get Them 41

Table 1: Means and Standard Deviations of Ratings for All Jobs in Phase 2 59

Table 2: Proportion of Selected Jobs in the Labor Force 60

Table 3: SCANS Competencies Required for Generalized Work Behaviors 61

Interdependence Through Partnerships: Transforming Education 63

APPENDICES 83

National Science Foundation Resources 83

Occupational Skills Standards Projects 89

Educational Resources Information Center (ERIC) Science, Mathematics, Engineering, and Technology Resources 93

Educational Resources Information Center (ERIC) Academic Standard Resources 101

NSF/AACC National Roundtable on SMET Programs in Community Colleges 111

NEAL LANE
Director
National Science Foundation

At the National Science Foundation education and learning are at the core of our mission. We are committed to reaching all students at every level by promoting inquiry-based, hands-on learning experiences in science, mathematics, and engineering.

As we look to the future, we expect that employers will seek people who not only are well-versed in science and technology concepts, but are also adept at learning through experimentation, inquiry, critical examination, and discovery—all characteristics of research. Employers are most interested in highly trainable workers rather than in just highly trained ones.

Community colleges are at the forefront of this effort. We all know that community colleges play a key role in preparing students for the workplace of tomorrow. Almost 50 percent of undergraduate students are enrolled in community colleges, and two-year schools account for over one-third of all undergraduate student enrollments in science, math, engineering, and technology fields. These facts make community colleges a cornerstone of our system of undergraduate education, particularly in mathematics and the sciences.

At NSF we are also committed to *institution-wide* reform of undergraduate education. This comprehensive approach to reform is no small goal, for when I speak of institution-wide reform, I speak of breaking down longstanding barriers of all kinds

within educational institutions. These barriers—which have impeded student performance and achievement over many decades—include barriers between departments and disciplines, between bureaucracies and institutions, and even between institutions themselves.

This last point is particularly important for community colleges. To prepare students for the next level—either in the workforce or in academe—community colleges must overcome significant obstacles between the often substandard education of students at the K–12 level and the educational demands of the workplace and four-year institutions. Unfortunately—according to a recent NSF review of undergraduate education—community college faculty often face many financial and other barriers that prevent them from working closely with or developing meaningful partnerships with their colleagues in four-year schools, with business leaders, or with high school teachers.

Breaking down these barriers—barriers that impede reform of science and math education—is one reason why NSF programs like the Advanced Technological Education (ATE) program were created. ATE projects have sought to enable close cooperation and collaboration between community colleges, high schools, businesses, and four-year schools—so that students will be better prepared for the increasingly complex workplace of the 21st century.

I hope that this monograph will encourage all of us—and by that I mean NSF, our partners in government and industry, and all the institutions we support—to raise our sights and begin to commit ourselves to breaking down the barriers and building a bridge to a better system of science, math, and engineering education for the 21st century.

DAVID R. PIERCE
President
American Association of Community Colleges

Science, mathematics, engineering, and technology education has always held a prestigious place in our schools and colleges. This earned regard can be explained in part because only the brightest of our students have been able to navigate the complex formulas and intricate connections between the precise details that characterize these fields of study. They have earned respect, also, because graduates of these programs have been largely responsible for the discoveries and the applications that have made and kept America the preeminent economy in the world.

But the world has changed dramatically in the last three decades. Everyone is impacted by developments that are based on science and mathematics principles. Deterioration of the ozone layer, environmental pollution, disease epidemics, and technology everywhere, among others, have created significant ramifications in our daily lives, in the way we respond as responsible citizens, and in the choices we make for careers.

These changes elevate the importance of SMET education, not just for the exceptional student but for all students who pass through our education system. At the very least, every student must possess the fundamental competencies and knowledge necessary to understand and deal with the science and technology that permeate our lives. They must also be encouraged to take career paths that will lead to employment in the better-paid, higher-skilled workplace that has emerged.

For this to happen, significant changes must be made in our education system. This monograph suggests what some of the changes ought to be. In addition to casting a set of general guidelines for change, it offers a set of recommendations to a range of stakeholders in the system. You may not agree with all that is presented here; in fact, not all of the statements were agreed to by the roundtable participants who generated them at a special meeting held in Washington, D.C., on June 7–9, 1996. Our interest in holding this meeting and publishing its results was not to reach consensus on all points, but to raise issues and to put them before our national network of community colleges (and to other audiences) for consideration and discussion.

My special gratitude goes to the 20 national leaders who took time to share their ideas with us and to the National Science Foundation for supporting this activity.

On June 7–9, 1996, 20 national leaders met in Washington, D.C., to discuss the condition of science, mathematics, engineering, and technology education (SMET). The participants represented secondary education, local school boards, national organizations for community colleges and business, government agencies, organized labor unions, individual community colleges, universities, corporations, and the National Science Foundation. The meeting was conducted by the American Association of Community Colleges through a grant from the National Science Foundation.

Roundtable discussants were charged with two goals: 1) to establish general principles to build upon and guide improvements in these study areas and 2) to compose specific recommendations aimed at the range of stakeholders in SMET education.

The following details capture the highlights of the discussion.

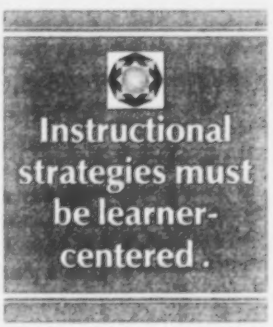
General Guidelines

1. **Relevance:** Science and technology have a tremendous and ever-increasing influence on the daily lives of people. They influence personal, civic, and work lives whether or not careers directly involve science and technology. Thus, it is vital that basic competencies and skills associated with SMET areas are taught in all schools and colleges from the earliest years, and that they be taught to all students, not just to those who are "academically inclined." SMET programs should be one of the pillars of general education. Part of this learning must include the understanding that these areas are not static and that to keep abreast of changes

in them requires a lifelong commitment to learning.

2. **Access:** We believe that consistent and energetic efforts must be made to ensure that all students have access to SMET programs on an equal basis. All barriers to fair participation in these programs must be removed, and strong efforts must be made to involve underrepresented students and to ensure their persistence in them.

3. **Benchmarks:** We believe that learning and performance benchmarks must be established at various points along the education continuum if improvement in SMET programs is to be achieved. A seamless education experience is a major goal of this benchmarking. A matrix of competencies must be constructed to ensure continuous skills and competencies development through the various levels of program and educational achievement.



4. **Instruction:** We believe that instructional strategies for SMET programs must change dramatically to achieve better results for continuing study as well as to match an expanding focus on practicality. Instructional strategies must be learner-centered, not institution- or faculty-centered. Instructors at all levels must be active learning facilitators, coaches and mentors, guides, and partners in learning, as well as sources of information.

5. **Partnerships:** We believe that SMET programs require the development and maintenance of effective, responsive partnerships among all levels of the education system and among all community groups that have an investment in the quality of the education system. Among the first group are K–12 schools, community colleges, four-year colleges and universities (both public and private), regional and state education organizations, ac-

crediting and licensing boards, and related national and governmental associations and agencies. Among the second group are business and industry, organized labor unions, civic organizations, parents, students, and others.

6. **Funding:** We believe that, to accommodate these necessary changes, significant new approaches to funding must be developed and applied. Successful application of this new paradigm will require different methods of organizing the classroom and the school day. Essential aspects of this reorganization include the creation of new means of assessing staff performance, new efforts to ensure that necessary instructional technology is available to all students at home and in the classroom, new relationships with the users of the system, and new methods of viewing the instructional units with accompanying formulas for supporting them.

7. **Global Dimensions:** We believe that the quality of our education system should be measured against the systems of other countries as well as against local and national norms. It is now axiomatic that large American firms are not the only enterprises that are trading globally. Medium and small firms across the country are marketing their products and services over the globe. A workforce that is not educated and trained as effectively as one from another country will not be able to compete successfully with that nation.

A workforce that is not educated and trained as effectively as one from another country will not be able to compete successfully with that nation.

RECOMMENDATIONS TO STAKEHOLDERS

1. **Community Colleges:** Contribute to the national standards movement, both industry skill standards and voluntary academic standards.
2. **Students:** Identify what is blocking successful SMET learning and recommend adjustments to faculty and administrators.
3. **Faculty:** Participate in developing and employing new and innovative curricula that address SMET competencies; and design interdisciplinary, discovery-based courses that provide general literacy in SMET.
4. **Academic Support Personnel:** Participate in discussions and planning to identify foundational skills students need.
5. **Academic Administrators:** Endorse the importance of SMET and provide opportunities for faculty across disciplines to get together and identify strategies for enhancing SMET learning for all students.
6. **Chancellors and Presidents:** Recognize and reward innovation in achieving more student learning in SMET.
7. **College Boards/Trustees:** Adopt policies and provide adequate resources for institutional leadership in promoting SMET activities for all students in the community college environment.
8. **Four-year Colleges and Universities:** Work more closely with other members of the higher education community to reduce barriers to student transition and transfer and to improve the effectiveness of the educational system.
9. **Government:**
   - **Local:** Make budgetary decisions based on the recognition of the unique demands of SMET education.
   - **State:** Provide flexible funding support to achieve SMET goals.
   - **Federal:** Establish incentives for the state and local governments to redesign their SMET programs for K–16.

Competencies and skills taught in science, mathematics, engineering, and technology (SMET) programs in our schools and colleges lead to high-skilled, higher-paid jobs in the economy. These competencies and skills also create a foundation that prepares students to effectively manage the increasingly technical character of our lives, from manipulating personal computer software programs, to participating intelligently in community discussions regarding local environmental issues, to planning and costing out do-it-yourself home repairs.

Historically, SMET program areas have enjoyed special status in our schools and colleges. They have been sublimely isolated from other programs. These courses were generally populated with "the best and the brightest" of our students. They were clearly so different from other disciplines (especially the humanities) that there was little consideration of melding them with other academic or technical areas. And the speciality equipment required in the courses distinguished them as well.

While lip service was given to the notion that science and math were important for everyone to know, at least to a particular level, little was done to insist that everyone possess fundamental capacities in these areas. The "smart" ones got the benefits; the "slower" ones did not.

All of this must change. SMET programs are essential for all students. A clear sequence of standards must be created throughout the schooling system to ensure appropriate levels of achievement at various stages of learning (a matrix or laddering of skills and competencies). While they point to oppor-

tunities in the workworld, these skills and competencies have clear relevance for both the personal and civic lives of students.

To build a rigorous and relevant sequence of dovetailed SMET programs, systemic change is required. To create this change, active partnerships with all of society's stakeholders must come together and contribute—their time, expertise, experience, physical resources, and money.

Teachers and faculty will have to change. Students will have to change. Funding sources, accreditation agencies, licensing boards, and other established components of the American education system must change to accommodate the kinds of program innovation outlined in this report. Communities and parents will have to be more involved, particularly in understanding and communicating the vital importance of science and mathematics in everyone's life.

GUIDING PRINCIPLES

We believe that the skills toward which SMET programs aim are important for all students at all levels to know and develop. Generic skills in these instructional areas address the concerns of all three focuses of education (personal, civic, and employment development) and should be introduced using a cross-discipline approach.

RELEVANCE

Science and technology have a tremendous and ever-increasing influence on our daily lives. They influence our personal, civic, and work lives whether or not our careers are ones directly involving science and technology. Thus, it is vital that basic competencies and skills associated with SMET areas are taught in our schools and colleges from the earliest years, and that they be taught to ***all*** students, not just to those who are "academically inclined." Part of this learning must include the understanding that these areas are not static and that to keep abreast of changes in them a lifelong commitment to learning is essential.

Responsibility for broadcasting the importance of SMET programs and principles does not fall exclusively on educators. Parents, community organizations, and the public and private sectors all must play a role in informing students of the important relevance of these studies for success in all phases of their lives.

At the community college level, the skills development should not be confined only to the standard academic disciplines. SMET programs should be of-

fered in a required survey course at the freshmen level whose focus would be the practicality of these skills for all dimensions of life and education.

ACCESS

We believe that consistent and energetic efforts must be made to ensure that all students have access to SMET programs on an equal basis. All barriers to fair participation in these programs should be removed and strong efforts must be made to involve underrepresented students and to ensure their persistence in them.

Community colleges must reaffirm their commitment to open access.

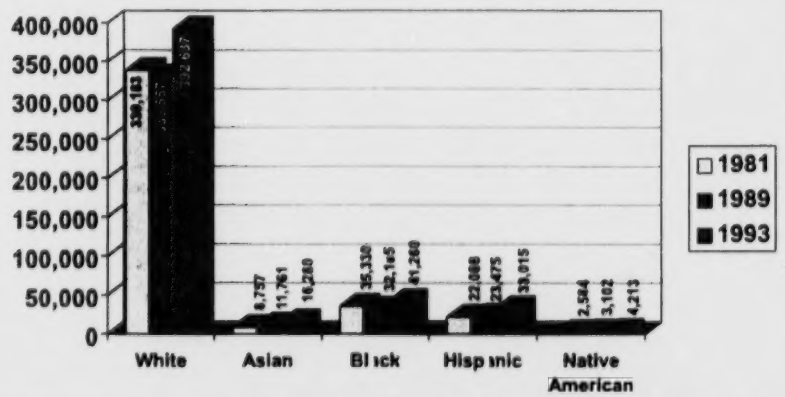
- **Open access.** Community colleges must reaffirm their commitment to open access. Open admissions means that many students will arrive at college with educational deficiencies that must be addressed. Effective foundation programs must be a standing part of SMET education to permit students who are not adequately prepared a chance to prepare for careers in emerging, better paid fields.
- **Remediation.** Because remediation is expensive, community colleges should collaborate with other stakeholders to help reduce the number of students who need this assistance—and to reduce costs—community colleges must enter into partnerships with the K–12 system to help ensure that students develop fundamental skills and competencies for the next level of SMET programs.
- **Tracking.** Traditional tracking patterns in high schools, which have placed only the "brightest" students in math and science programs, must be changed. This would eliminate the current constricted pipeline to more advanced SMET course work in college.

"brightest" students in math and science programs, must be changed. This would eliminate the current constricted pipeline to more advanced SMET course work in college.

- **Students.** Student confidence and persistence must be buoyed. Research appears to support the theory that success in SMET education, in particular, is a function in important ways of a student's confidence level—the "I can do it" belief. Such confidence is often a function of a student's "cultural mandates" and the importance assigned to achievements in particular career areas. One major result of these mandates is there are several groups are underrepresented in SMET programs, particularly minority and female students. Factors that encourage and discourage student involvement in SMET programs need to be

Earned Science & Engineering Associate Degrees

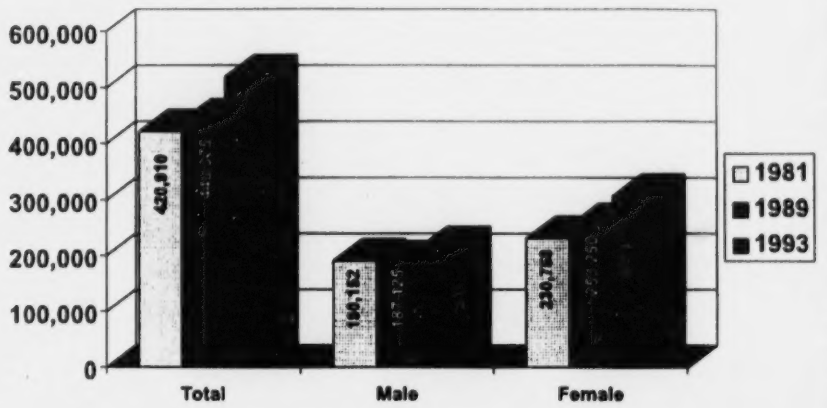
by Ethnicity: 1981,'89,'93



Source: National Center for Education Statistics, Earned Degrees & Completion Surveys, unpublished tabulations; and Science Resources Studies Division, National Science Foundation, unpublished tabulations

Earned Science & Engineering Associate Degrees

by Gender: 1981,'89,'93



Source: National Center for Education Statistics, Earned Degrees & Completion Surveys, unpublished tabulations; and Science Resources Studies Division, National Science Foundation, unpublished tabulations

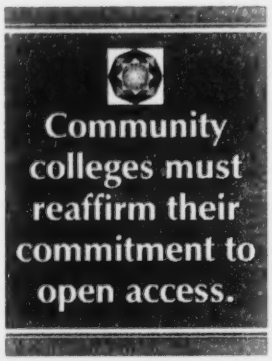
accompany all such offerings. Mentoring, role modeling, study groups, tutoring, responsive advisement and counseling, and other techniques must be an aggressive part of school and college programs. Information about careers leading from SMET study should be easily available and freely distributed to students, and other opportunities to learn first hand about such careers (career days, guest speakers, etc.) should be a standing part of these curricula. Also, parents should have access to this information and should be encouraged to talk with their children about it.

- **Technology.** Technology must be readily available to every student to facilitate learning. Special resources and approaches must be found to accommodate students whose family circumstances inhibit ownership of computers and other equipment essential to SMET studies.

Technology must be readily available to every student to facilitate learning.

- **Institutional research.** Comprehensive surveys and/or exit interviews should be conducted for students who do not successfully complete SMET education courses and programs. The profiles should be shared with administrators, faculty, and other stakeholders and used as a means of appropriately altering those parts of the offerings that most frequently lead to failure.

BENCHMARKS



We believe that learning and performance benchmarks must be established at various points along the education continuum if improvement in SMET programs is to be achieved. A seamless education experience is a major goal of this benchmarking. A matrix of competencies must be constructed to ensure continuous skills and competencies development through the time students choose to leave the system.

A permanent process must be established to generate and continually reaffirm or adjust standards of learning which all students must reach. These benchmarks should clearly identify what students should know and what they should be able to do as they progress through their education. The benchmarks should be set at reasonable points from kindergarten through professional degrees.

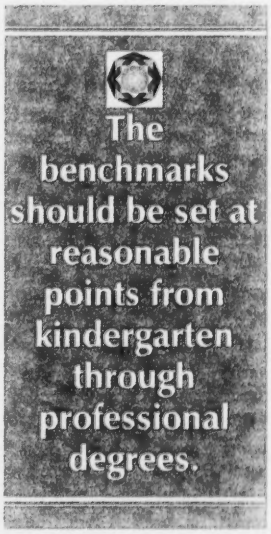
The work already completed in this area for academic standards (Goals 2000) and for skills standards (SCANS) provides good starting places for the creation of full-system benchmarks.

- **Real needs.** SMET benchmarks should be based on identified community and indus-

should know and what they should be able to do as they progress through their education. The benchmarks should be set at reasonable points from kindergarten through professional degrees.

The work already completed in this area for academic standards (Goals 2000) and for skills standards (SCANS) provides good starting places for the creation of full-system benchmarks.

- **Real needs.** SMET benchmarks should be based on identified community and industry-based needs and on the requirements of baccalaureate institutions.
- **Student competence.** New assessment tools must be created to determine student mastery of the required concepts and competencies. And, a record of the progressing skills and competency development of each student must be kept so that students have a history of their achievement in the education system.
- **Measurement tools.** Both the development of standards and the devices employed to measure learning and competencies must be designed by teams composed of educators at all levels, community representatives, and business officials to achieve acceptance across the users of the system.
- **Models.** One useful model to consider for these purposes is the allied health programs now offered in community colleges. These programs, such as the associate degree in nursing, point to clearly defined careers requiring specifically defined skills and competencies for different activities. Instructional approaches include didactic and clinical experiences that directly connect classroom studies with their application in real situations.



the eighth grade. According to The College Board, enrollment in algebra by the eighth grade correlates highly with success on the SAT.

- **Credentials.** Successful achievement at various levels of education should be a signal to employers that completing students possess identifiable skills and competencies. At some point in the near future, completion of a community college program may be the credential required for entry-level employment.

INSTRUCTION

We believe that instructional approaches to delivering SMET programs must change dramatically to achieve best results and to match the expanding focus on practicality. The critical skills to which these programs should be aimed must be learner-centered, not institution- or faculty-centered. Instructors at all levels must be viewed as learning facilitators, coaches and mentors, guides and partners in learning—not as the ultimate sources of all learning.

Instructors at all levels must be viewed as learning facilitators, coaches and mentors, guides and partners in learning—not as the ultimate sources of all learning.

The learning and skills toward which education aims must include individual and collaborative problem-solving, analysis, understanding, reasoning, and reflection, not memorization of staid formulas or abstract relationships unrelated to real-life situations or conditions. Rather than employing the standard lecture-dominated and memorization traditionally applied in these programs, new contextual learning approaches must be used that enhance practical learning and show students the applications of these studies to real-life situations. Curriculum must be redesigned for the same purposes.

The learning and skills toward which education aims must include individual and collaborative problem-solving, analysis, understanding, reasoning, and reflection, not memorization of staid formulas or abstract relationships unrelated to real-life situations or conditions. Rather than employing the standard lecture-dominated and memorization traditionally applied in these programs, new contextual learning approaches must be used that enhance practical learning and show students the applications of these studies to real-life situations. Curriculum must be redesigned for the same purposes.

New contextual learning approaches must be used that enhance practical learning and show students the applications of these studies to real-life situations.

To accommodate these changes, a variety of approaches must be applied.

- **Faculty.** Professional development opportunities of various sorts must be structured for faculty. These opportunities should include:

  participation in seminars or workshops focused on curriculum design and instructional innovation;

  release time to rewrite curriculum;

  release time to work with other faculty to link courses, to create team teaching strategies, and to prepare other materials and approaches compatible with the new paradigm;

  release time to incorporate technology into instruction;

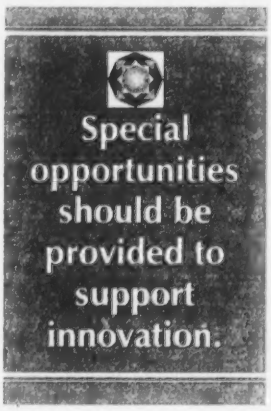
  release time or the use of other mechanisms to provide opportunities to learn about the actual demands of the workplace (exchanges with industry employees, shadowing opportunities in business and industry, formal meetings with business and industry representatives centered on curriculum concerns, and others);

participation in regional or national meetings that are designed to investigate new approaches to the delivery of SMET instruction;

involvement in funded demonstration programs;

collaborative meetings with secondary school instructors and with four-year college and university faculty to help ensure that changes at one level are not made in isolation from the rest of the education system.

Principal funding for these activities should be provided in institutional budgets with supplementary assistance provided by state monies and by national grants and contracts. At the national level, government agencies like the National Science Foundation and the U.S. Department of Education should establish special funding programs to support model programs development across the education continuum. These funding sources should provide opportunities for special efforts that fall outside of the purviews of established departments. That is, special opportunities should be provided to support innovation.



A significant number of elementary school teachers begin their higher education at community colleges where they take the only mathematics and science courses of their postsecondary career. Provisions should be made to ensure that these students are literate in SMET areas. Articulation agreements between community colleges and transfer institutions should be structured to require that preservice teacher education students are adequately grounded in SMET concepts and principles before they are called upon to teach them in the schools.

If SCANS standards are adopted as part of an institution's instructional package, appropriate assessment devices are needed here as well. Further, if the national movement toward academic standards in the K–12 system, triggered by the Goals 2000 national initiative, is adopted nationwide, comparable and compatible standards and assessment tools must be developed to create a continuous flow of achievement.

- New assessment tools must be developed to evaluate the instructional techniques of teachers. The focus of these assessments should fall on the range of instructional techniques faculty use to assist student learning. Included among the targets of such assessment would be: the effectiveness of collaborative learning exercises devised, the appropriateness of real-life problems shaped, the application of technology in the learning environment, the patterns of coaching and mentoring used, and the information resources released, among others.

The new tools should focus on three areas: student learning, instructor effectiveness, and curriculum currency.

- Assessment approaches must also be created to guarantee the currency of programs, especially those in the occupational/technical arenas. Periodic meetings of curriculum advisory committees (composed in large measure of employer representatives) is one such assessment tool. Others include: faculty internships in business and industry settings, the use of private sector instructors in team-teaching arrangements or as single instructors, the use of the DACUM approach to curriculum design, the systematic and periodic survey of employers to identify the strengths and weaknesses of program graduates, and various other data collec-

Assessment approaches must also be created to guarantee the currency of programs, especially those in the occupational/technical arenas. Periodic meetings of curriculum advisory committees (composed in large measure of employer representatives) is one such assessment tool. Others include: faculty internships in business and industry settings, the use of private sector instructors in team-teaching arrangements or as single instructors, the use of the DACUM approach to curriculum design, the systematic and periodic survey of employers to identify the strengths and weaknesses of program graduates, and various other data collection techniques aimed at other "users" of program graduates.

In each of these cases, a comprehensive database should be established to track the relative achievement of students, faculty, and programs. The database would be a significant aid to ensure the continuous quality improvement of each aspect of the effort.

The database would be a significant aid to ensure the continuous quality improvement of each aspect of the effort.

- **Curriculum.** To strengthen student science, mathematics, engineering, and technology competence, all education levels must be participants so a continuum of development will be created. Four levels of competence should be considered:

  1. General knowledge and appreciation of basic SMET concepts;
  2. General SMET skills required for employment and every-day life purposes;
  3. Specific SMET skills required for specific career clusters; and,
  4. Specific SMET skills required for a specific career.

For levels two through four, curricula should:

a. Be based on industry defined, competency based criteria;

b. Include various work related experience (apprenticeships, internships, work study, service learning, etc.);

c. Contain continuous quality measures;

d. Be assessed by program partners (business, industry, organized labor unions, public organizations, etc.);

e. Include provisions for evaluating student progress longitudinally through the education system and the student's career;

f. Provide a process for continuous evaluation and progression;

g. Identify specific learner outcomes throughout the stages of learning;

h. Lead to an official diploma, certificate, or degree that is recognized and valued by employers and that is accepted for transfer by four-year colleges and universities.

Further, the curriculum should be designed to prepare students for the demands of the marketplace and the community ten years into the future.

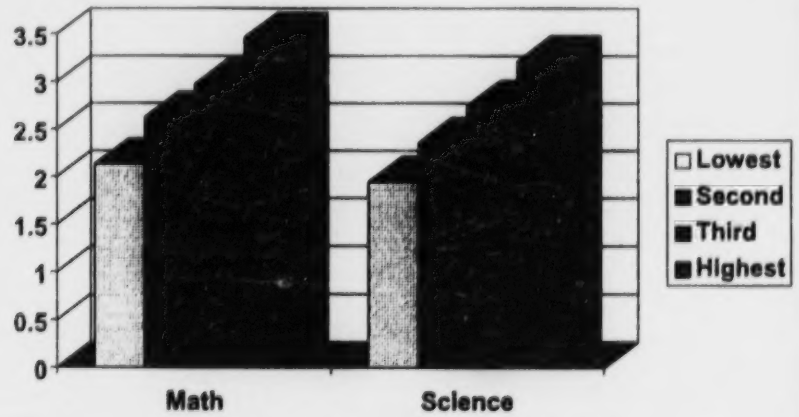
As has been noted in other places in this statement, an effective SMET curriculum must be the result of all elements of the education system and their partners actively participating in the design. Skills and competencies must be sequenced through the whole education experience, with those at one level serving as the foundation for those at the next higher level. This requirement argues for systemic reform. It is required to reach the ultimate goal of a seamless education system.

Further, the curriculum should be designed to prepare students for the demands of the marketplace and the community ten years into the future. The extraordinary pace of change requires a forward look of at least this magnitude.

Also, the traditional insularity of SMET programs must be altered. At the community college level, it is not unusual for a student to take only one course in the SMET cluster. At the four-year college and university levels with the dissolution or reduction of core courses and course requirements, general student involvement in SMET studies has declined considerably. The skills and competencies taught in these courses are lost as a result. One way to reduce these losses and to give students opportunities to learn these skills and competencies is to imbed SMET elements into other disciplines. It would not be much of a stretch, for example, to insert SMET problems in art,

Average Number of Math & Science Classes Completed by High School Students

by Socioeconomic Status: 1992

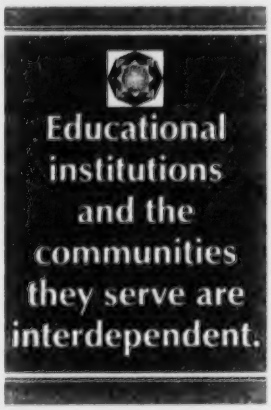


Source: T.B. Hoffer, et al., Social Background Differences in High School Mathmatics & Science Coursetaking & Achievement, NCES 95-206 (Washington, DC: NCES, 1995).

dance, literature, or history. Faculty collaborations across disciplines for these purposes could produce creative lessons or modules usable in any of the disciplines. Interdisciplinary partnerships are now common in the humanities. Creative collaborations could make it common between the humanities and SMET programs.

PARTNERSHIPS

We believe that SMET programs require the development and maintenance of effective, responsive partnerships among all levels of the education system and among all community groups that have an investment in the quality of the education system. Among the first group are K–12 schools, community colleges, four-year colleges and universities (both public and private), regional and state education organizations, accrediting and licensing boards, and related national and governmental associations and agencies. Among the second group are business and industry, organized labor unions, civic organizations, parents, students, and others.



Educational institutions and the communities they serve are interdependent. Improvement in either cannot be achieved without the intimate and active involvement of the other. While education is good in and of itself, it is driven by practical purposes in three broad areas: personal development, civic responsibility, and work. To be effective and useful, education has to know, keep pace with, and respond to the clearly defined demands of each of these areas. It must be able to convert responses to the following questions into curricula that will help

students learn the competencies and personalize the knowledge required to create a whole person. The broad questions are:

> What is required to gain personal fulfillment?
>
> What behavior must an individual exhibit to be civically responsible in a democratic society?
>
> What must a person be able to do and know to gain and hold a satisfactory job?

The answers to these questions cannot come from educators alone. They must emerge from other sectors of the community who live them, who are most intimate with the requirements. They must come from the "users" of the education system.

Educators should initiate collegial partnerships with all of these groups and others to ensure that what they offer in their classrooms is truly connected to the way life is lived in the communities they serve, whether the community is local, regional, statewide, national, or international. In the words of one of our roundtable participants, education is too important to leave in the hands of educators alone. The entire community must play an important role to identify its directions and goals.

A seamless education system demands a culture of collaboration that has not been evident to this point in history.

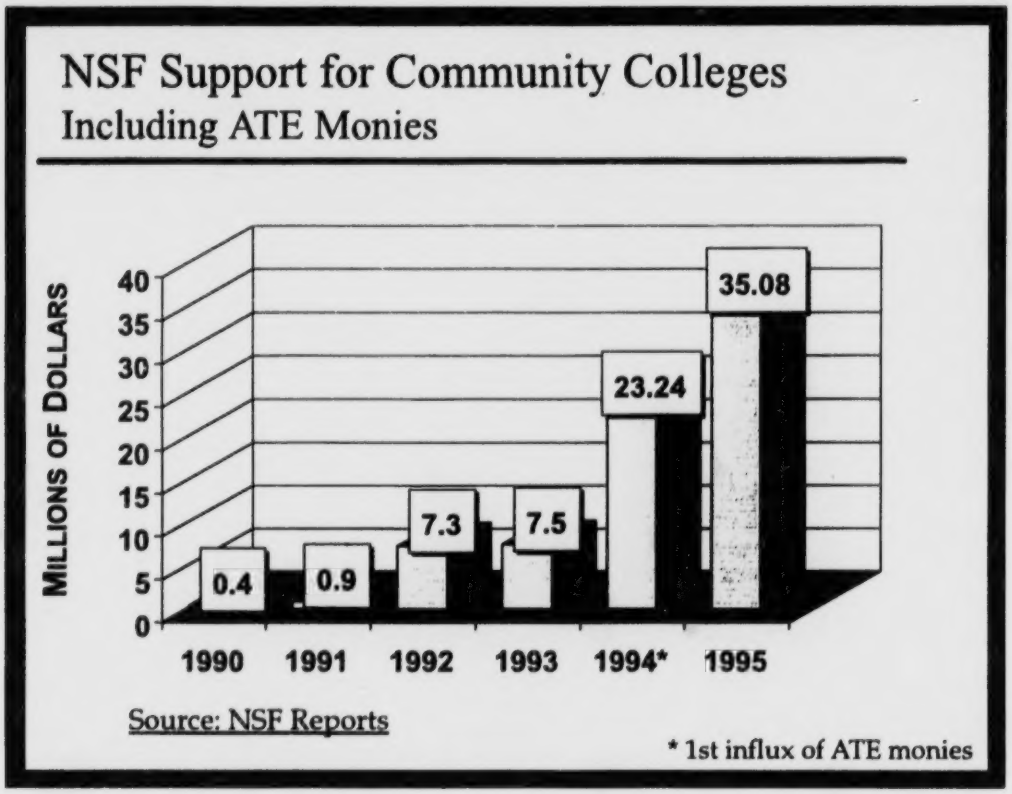
Probably better than other types of postsecondary institutions, community colleges have involved their communities in shaping their educational programs. They have been especially sensitive to the need to work with employers to design and adjust occupational and technical curricula. These colleges have placed less stress on other components of the community. They need to more formally involve these other sectors in their work.

Change must occur at all levels of the education enterprise. Improvement in one location of the education stream will have little impact if related and complementary changes are not made in all other locations. What is needed is systemic change. Systemic change requires that all components of the system adopt the principles of change and apply them at their levels. It also requires that all levels work closely together, consistently and over the long run. A seamless education system demands a culture of collaboration that has not been evident to this point in history.

The academic standards movement in K–12, triggered by the national Goals 2000 program, offers a rich opportunity for higher education collaboration. While application of the standards is uneven within states and across states, colleges and universities should be lending their hands and expertise to the work of making it successful. Colleges and universities should be assisting with curriculum development, creation of assessment procedures and tools, enrichment of instructional techniques, and wider teacher professional development. They should be working with the schools to meld the new programs with the colleges' to create a smooth transition from school to college, from school to work, and from work to school for students, not just in curricula areas, but also in instructional techniques and in student learning approaches. The colleges and universities should adjust their own programs to complement those of the high schools so that there will not be a significant jar or disruption when a student moves from one to the other.

Colleges and universities appear to have ignored the K–12 standards movement, looking at it as a curiosity rather than as an opportunity to assist in making significant improvements in the system.

There does not appear to have been a great deal of this collaboration to date. Colleges and universities appear to have ignored the K–12 standards



movement, looking at it as a curiosity rather than as an opportunity to assist in making significant improvements in the system. The possible effects of national goals and standards on postsecondary education are not discussed with any great energy in annual meetings, in the higher education press, or in scholarly works.

We run the risk of being inundated by the changes that are occurring in the schools. With the application of new standards (all of which come with new technology, with new teaching approaches, with new skills development), the students coursing into our college classrooms in the near future could be very different from what they are today—more advanced in their academics, more capable of demonstrating knowledge, better able to pursue lines of intellectual investigation independently, expectant of

relating to teachers as coach/student rather than as lecturer/student, and more experienced in the use of technology in support of learning).

The new student will require a new college—adjusted curricula, altered teaching techniques, improved technology, and important shifts of other sorts. The speed at which these changes will occur is uncertain; but it won't be overnight. Yet, the fact that changes are happening in the schools that feed our colleges suggests that we ought to be directly involved with the schools even from the beginning—to help them make required changes and to help us design our own responsive systems to these changes.

The only discipline at the community college level that has joined in these dynamics is mathematics.

The only discipline at the community college level that has joined in these dynamics is mathematics. Recently, the American Mathematics Association of Two-Year Colleges (AMATYC) developed national mathematics standards for community colleges. More such work needs to be undertaken.

Another national education movement that has not received adequate broad-scale attention by colleges and universities is the Secretary's Commission on Achieving Necessary Skills (SCANS) program. In the early 1990's, the Commission issued a report that outlined the skills young people need to succeed in the world of work. The Commission's purpose was to create an education system designed to prepare students for high-skilled, high-performance, high-wage employment and to boost the international competitiveness of the American economy. While recognizing that education has several purposes (the intrinsic value of an education for personal growth, preparation for effective participation in a democratic society, parenting, among them), the SCANS reports stressed standards and assessment tools aimed at

developing and quantifying basic competencies required in the new economy. The application of these standards to students at about age 16 and continuing through approximately age 21 would result in a sequence of portable certificates, diplomas, and degrees that would tell employers that these students possessed specific workplace skills required in jobs.

The sequence of skill-building would begin with basic foundation skills necessary in both work and non-work situations and progress through more specific competencies required in the workplace. In every case, while a specific cluster of occupational jobs would be the target, the competencies would be shaped to create the kind of worker flexibility that would allow movement around and between occupational clusters as well as permit student transfer into higher level academic and professional learning at the baccalaureate or higher levels.

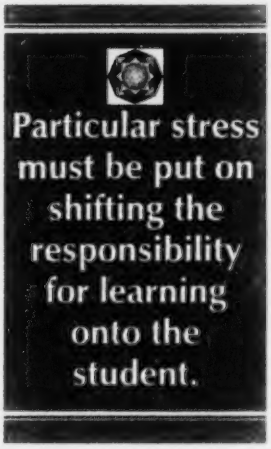
The new teaching and learning process will require a different kind of relationship between students and instructors.

In all of this anticipated change, one special partnership must be emphasized—the partnership between students and their institutions of learning. The new teaching and learning process will require a different kind of relationship between students and instructors. Particular stress must be put on shifting the responsibility for learning onto the student. Students should be viewed as primary actors in their own education. That is, students should be viewed as developers of their own education, aided and guided by faculty. Students should be responsible for learning, responsible for independent reflection on what interests them and on what they need, responsible for working with others in joint problem-solving, and responsible for generating the highest level

of achievement possible. They should not be viewed as passive vessels to be filled by faculty, but as aggressive managers of their own educational development.

This conversion is not meant to free students to pursue their own whims and fancies but with the coaching and guidance of the teacher to investigate, experiment, problem-solve, and generate conclusions with much of their own initiative using the foundations of scientific principles.

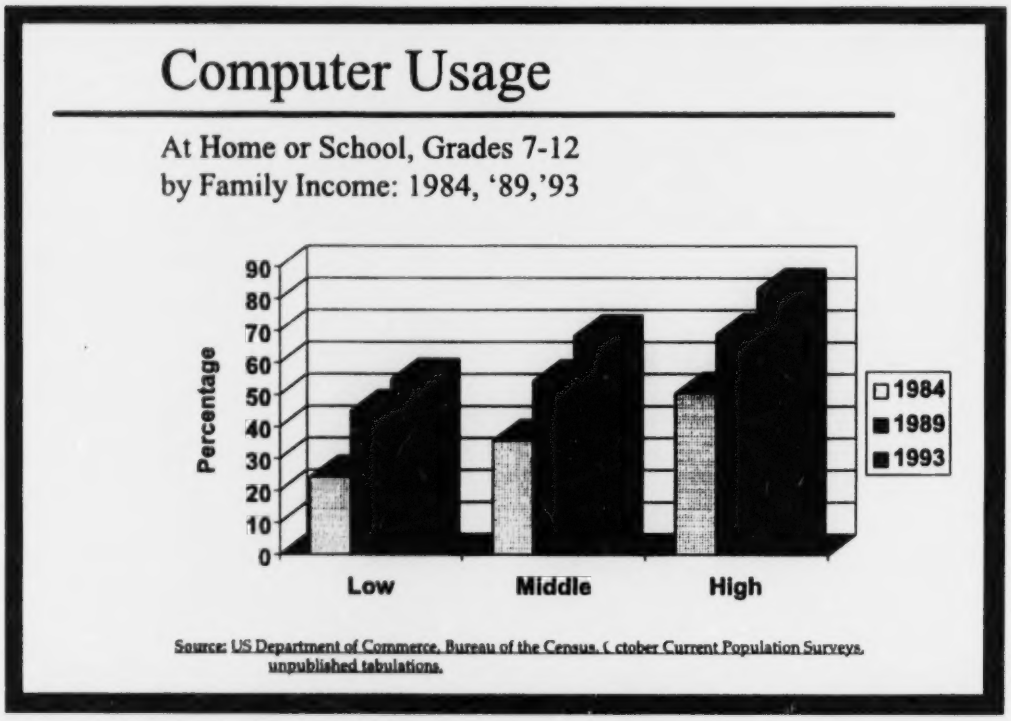
For this to happen, schools and colleges must develop a new learning culture. Instructors must convince students that they are truly committed to relinquishing their traditional authority role, are committed to partnering with students, and truly want them as engaged partners in the teaching and learning process. With this approach, students will not be given knowledge and skills, they will earn them.



FUNDING

We believe that to accommodate these necessary changes significant new approaches to funding must be developed and applied. Successful application of this new paradigm will require different methods of organizing the classroom and the school day. Essential aspects of this reorganization include the creation of new means of assessing staff performance, new efforts to ensure that necessary instructional technology is available to all students at home and in the classroom, new relationships with the users of the system (communities—including local, state, and national venues and individual organizations in each of these communities), and new methods of viewing the instructional units with accompanying formulas for supporting them.

Traditional methods for funding these innovations will not work. Different funding patterns must go hand-in-glove with system change. Investment in these changes must be greater in sum than they have been. Education cannot take a back seat to the com-

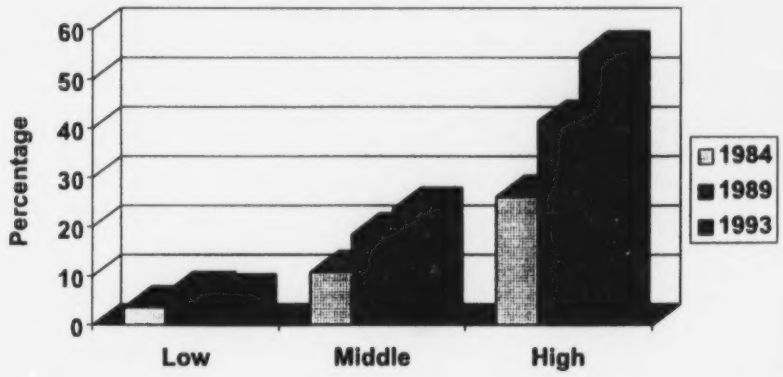


pelling demands of health and corrections costs that are consuming an ever increasing percentage of government budget allocations.

In the same spirit that all the stakeholders in education must be involved in shaping standards, assessment tools, and the general directions of education at all levels, they must participate in the financial support of these changes. Appropriate federal agencies must shift and expand their funding patterns to encourage these changes. State organizations must find the means to increase the flow of monies for innovation in these programs. Schools

Computer Usage

At Home Only, Grades 7-12
by Family Income: 1984, '89,'93



Source: US Department of Commerce, Bureau of the Census, October Current Population Surveys, unpublished tabulations.

and colleges must use their creativity to restructure their budgets to ensure resources are available to stimulate these changes. The private sector must release its considerable resources to bear greater responsibility for system improvement, including: making more opportunities for workplace learning; releasing staff to serve as teachers, curriculum designers, role models, tutors, mentors; donating equipment; making equipment available to schools and colleges either on-site or through electronic connections; sharpening their own development projections so that appropriate curriculum can be shaped in the schools and colleges; and encouraging their employees to train and retrain throughout their employment. Organized labor unions, both education- and industry-based, must include in their negotiated contracts provisions that accommodate and encourage the kinds of changes required by this new paradigm. Parents and students should expect to pay more for participation in these programs.

Global Dimensions

We believe that the quality of our education system should be measured against the systems of other countries as well as against local and national norms. The economic strength of our communities and our nation increasingly depends on the competitiveness of our business and industry. It is now axiomatic to state that large American firms are not the only enterprises that are trading globally. Medium and small firms across the country are marketing their products and services over the globe. A workforce that is not educated and trained as effectively as one from another country will not be able to compete successfully with that nation.

For this reason, it is important that dialogues be created and sustained with other countries so a common understanding of educational standards, workforce needs, and assessment approaches can be developed. It is also important to encourage the sharing of successes and failures in these efforts.

The economic strength of our communities and our nation increasingly depends on the competitiveness of our business and industry.

RECOMMENDATIONS TO STAKEHOLDERS

The following recommendations are aimed at various stakeholders in SMET education. They highlight significant activities on which stakeholders should focus to stimulate improvement in these education areas.

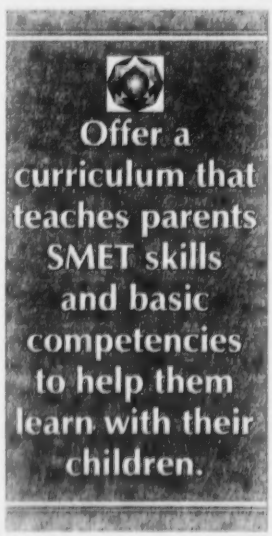
COMMUNITY COLLEGES

- Pay more attention to the national movement to standards, both industry (skill standards) and academic, at the K–12 level and higher. The impact of these movements could have great impact on all parts of the system. It is especially important for two-year colleges to work with K–12 systems to assist with the implementation of new curricula, new learning approaches, and new assessments that accompany the standards. Professional development of K–12 faculty is one important way that community colleges can contribute. Further, community colleges must work with the four-year colleges and universities on the same issues.
- Improve student academic advising at the entry level and beyond with realistic presentation of what is required to be successful. Funding and staffing for advising should be enhanced to achieve this goal. Matriculation agreements between two-year and four-year colleges and universities should be developed to add predictability to student career plans.
- Petition for state approval to offer K–12 teacher professional development progams that focus on SMET competencies and benchmarking skills.

- Offer a curriculum that teaches parents SMET skills and basic competencies to help them learn with their children and to avoid their reluctance to help because they have less conceptual knowledge in SMET than their children. This could be a powerful paradigm to get them comfortable enough for their children to become their teachers and, thus, to increase their children's learning.

STUDENTS

- Explore the application of SMET competencies and learning to fulfill employment goals. Students must shift their motivation for learning and dedicate themselves to disciplined, sustained learning.
- Participate in orientation programs to prepare them for SMET related subjects.
- Identify what is blocking them from learning the SMET competencies. With that knowledge, learning experiences can be redesigned to ensure more learning in SMET.
- Participate in model pilot programs that are interdisciplinary, team-oriented, problem-solving oriented and that emphasize SMET competencies and document their experience for the benefit of other students.
- As alumni, relay testimonials of the importance of SMET skills in the workplace.



FACULTY

- Introduce basic SMET principles into all courses of study.
- Participate in team-teaching activities between SMET and other discipline specialists.

- Play an active role in student advising activities, both the career and academic advising as well as for mentoring activities.
- Provide case study models for classroom study.
- Participate in developing or employing new and innovative curricula that addresses SMET competencies, such as interdisciplinary studies and learning communities, team-work, problem-oriented curricula.

SMET Faculty

- Meet with non-SMET faculty to discuss what really needs to be learned and develop ways in which the SMET competencies can be taught across disciplines.
- Treat all students with respect and dignity, and create an environment where all students feel that they can succeed.
- Update course content with technological advancements.
- Provide ideas that specifically challenge the student's ability to apply the material learned.
- Identify community college students with high SMET potential and encourage advanced coursework for them at four-year institutions.
- Spend a portion of their time working and communicating with businesses and industries in their regions. College administration must help facilitate that by providing faculty time and resources for such activities.
- Design interdisciplinary, discovery-based courses that are designed to attract more students to general literacy in SMET and also that attract more students to consider a SMET career.

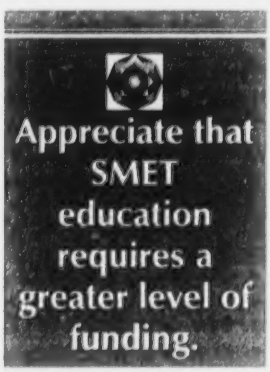
Students must shift their motivation for learning and dedicate themselves to disciplined, sustained learning.

Non-SMET Faculty

- ❖ Understand and appreciate the SMET competencies and how to teach them.
- ❖ Appreciate the importance of these skills and cooperate with SMET faculty to incorporate principles into the non-SMET courses.
- ❖ Avoid protective and confrontational attitudes toward SMET education and support increased funding that is needed for these eduational programs.

ACADEMIC SUPPORT PERSONNEL

- Participate in discussions and planning what students need as foundational skills.
- Work with students in a holistic manner to provide assistance in goal setting, personal counseling, and other support activities that will ultimately result in employment or transfer.
- Develop an understanding of SMET education and the competencies required by industry.
- Insist that the college community view academic support as a significant cog in the whole education process.

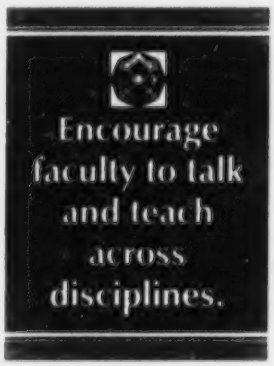


ACADEMIC ADMINISTRATORS

- Endorse the importance of SMET and provide opportunities for faculty across disciplines to get together and identify strategies for enhancing SMET learning for all students. They should work at the state level with their counterparts to develop statewide benchmarks and/or competencies. Academic administrators should work with their

peers in identifying and implementing assessment strategies.

- Talk with business and other stakeholders to determine practical needs of programs.
- Appreciate that SMET education requires a greater level of funding and must have the courage to support such funding over the objections of non-SMET faculty groups.
- Pay closer attention to retraining and faculty development to support changes in curriculum, pedagogy, and the application of technology.

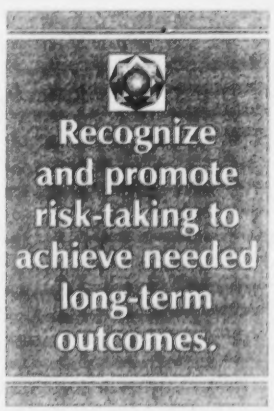


PRESIDENTS/CHANCELLORS

- Guide their institutions through this transition and position human and fiscal resources to meet the challenges.
- Endorse the importance of SMET as well as liberal arts.
- Build strategies into the planning and budgeting processes that will encourage faculty to talk and teach across disciplines.
- Recognize and reward innovation in achieving more student learning.
- Find out what is happening at other colleges and K–12 schools and borrow the best for their own institutions.
- Be willing to stand up for increased financial support for SMET programs.
- Require and support excellence in SMET programs. They must demand that all programs at the college meet national standards, if they exist. Accreditation for programs should be a goal.

COLLEGE BOARDS/TRUSTEES

- Adopt concrete policies and provide adequate resources for the institutional leadership in promoting SMET activities for all students in the community college environment.
- Support presidents/chancellors to re-engineer their institutions into fast response teams who can react to technological advancements without losing site of institutional integrity.
- Forfeit attempts to control day-to-day operations of the college and keep focused on large, long-term policy issues and planning for the institution. In this longer-term focus, the board should resist short-term fixes that will create long-term problems.
- Recognize and promote risk-taking to achieve needed long-term outcomes.
- Establish policies that encourage innovation.
- Promote participation of local industry leaders on college boards, to assure knowledge of industry trends and direction.
- Encourage the development of a strong general education program in which SMET competence is a component.
- Establish through local boards of education the curriculum and support services necessary to have ***all*** students achieve minimum competencies in SMET. Once established, the local boards need to effectively communicate their importance to the parents, students, and community.
- Institute expanded appointment terms to encourage longer-term thinking and to avoid short-term, expedient political decisions.



OTHER EDUCATIONAL INSTITUTIONS

- Adopt and promulgate the SMET principles and recommendations identified in this document.

K–12

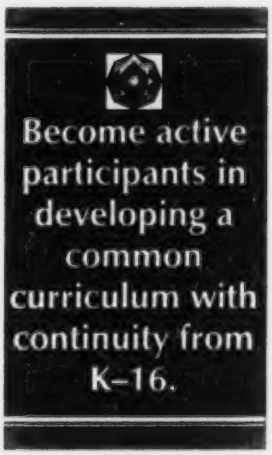
- ❖ Work willingly with community colleges to expose students to SMET on the K–12 level and to provide opportunities for interested and able students to co-enroll in college level courses, too.
- ❖ Use community-based support for the advancement of SMET centers or the like.
- ❖ Take an active role in developing common goals as partners in full systemic change.
- ❖ Support community colleges so they might obtain state approval to offer teacher education in SMET.
- ❖ Initiate innovative programs, such as college-in-the-high school, running start, online instruction in which double-credit (high school and college credit) are given for courses delivered by high school teachers.
- ❖ Work jointly with all of higher education to develop a seamless web of SMET learning and assess their current teaching and adopt new ways of structuring the learning for student success.
- ❖ Give greater institutional recognition to discipline-based SMET faculties in the administrative structure of the school system.
- ❖ Develop parent "empowerment" strategies to assist with the effective monitoring of the courses, academic

Use community-based support for the advancement of SMET centers or the like.

programs, and career selections of their children, particularly as they relate to SMET education.

Four-year Colleges and Universities

- ❖ Work more closely with other members of the higher education community to reduce the barriers to student transitions and transfer and to improve the effectiveness of our educational system.
- ❖ Become active participants in developing a common curriculum with continuity from K–16.
- ❖ Explore the possibilities of sharing faculty and facilities for enhanced educational opportunities for the citizens of the region.
- ❖ Consider the feasibility of including certain blocks of courses in transfer agreements as compared to course-by-course transferability.
- ❖ Develop creative programs to facilitate enhanced transfer opportunities, including the inclusion of bridge programs.



BUSINESS

- Provide employee opportunities for involvement in education and training programs.
- Provide funding for technology.
- Provide school-to-work opportunities.
- Provide work-study programs for SMET applications.
- Provide funding for development of specialized SMET application curriculum.

- Provide faculty with temporary jobs in industry to increase awareness of real-world SMET applications.
- Provide industry staff with temporary jobs in community colleges to increase awareness of SMET education.
- Participate in the development of SMET standards and levels of competency for technician and technologists programs.
- Participate in data panels to develop standards and competencies in specific SMET careers.
- Assist with the development of "real-life" problems for students in SMET curricula.
- Provide realistic laboratory opportunities at the industry sites and at institutions.
- Partner in student assessment and evaluation through work-based programs.
- Share, along with other stakeholders, the principles and recommendations noted in this document with local and regional Workforce Training Boards that will play a significant role in shaping policy for the region; ask that they be adopted and forwarded to regional educational institutions.
- Establish apprenticeship programs with local community colleges and high schools to assure availability of educated and trained employees.
- Provide opportunities for faculty-internship programs.
- Provide state-of-the art equipment to local colleges and universities.
- Provide incentives for parents to become involved in education/SMET goals.

Increase awareness of real-world SMET applications.

- Show a specific and active interest in summer-employed high school and college students in SMET programs and underscore the importance of school.
- Establish summer internship programs for community college students.
- Put programs in place to provide funding for students of employees and employees who wish to improve their competencies.
- Provide job notices to local community college students before they are broadcast in the open market.
- Provide non-exempt positions to needy community college students that must work to continue their education.

Support SMET relevance in the workplace at the national level.

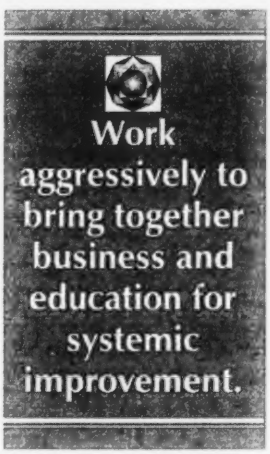
ORGANIZED LABOR

- Provide opportunities for school-to-work activities.
- Become an active participant and supporter of SMET goals.
- Negotiate compensation for continuing education.
- Negotiate for salary advancement based upon continuing education.
- Negotiate for the associate degree to be a required credential in technician and technologists positions.
- Support SMET relevance in the workplace at the national level.
- Serve on program advisory committees and help identify the competencies needed in SMET.
- Allow staff to reassess what is considered appropriate work by faculty and work with

administration on the overall funding available to community colleges so that as dollars get even tighter important long-term initiatives will not be dropped.

COMMUNITY ORGANIZATIONS

- Support and participate in education improvement programs and not simply expect "the schools" to do it.
- Work aggressively to bring together business and education for systemic improvement.
- Tap into private foundations for funding of some SMET initiatives at local and regional levels.
- Celebrate SMET successes at local schools and colleges.



PARENTS

- Take a much more active interest in the courses taken by their children as well as the time spent in doing homework and be the primary factor in getting their children to read, and read, and read.

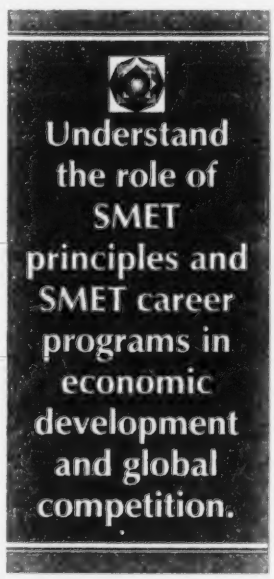
FOUNDATIONS

- Provide increased financial resources, such as scholarships and grants.
- Establish funded projects that develop and then duplicate and disseminate effective programs to teach SMET.
- Broaden the scope of acceptable funding initiatives, encouraging innovation and creativity.

GOVERNMENT

Local

- Make budgetary decisions based on the recognition of the unique demands (class size, employee compensation, equipment, facilities maintenance, etc.) of SMET education.
- Institute maintenance of effort requirements for general and SMET education.
- Support cooperation between community colleges and industry to assure local economic growth.
- Understand the role of SMET principles and SMET career programs in economic development and global competition.



State

- Provide flexible funding to activate SMET goals.
- Assure cooperation between community college and industry to support continuous employment.
- Establish minimum competencies expected for ***all*** high school graduates in SMET on the basis that ***all*** students will need postsecondary education if they are to participate satisfactorily in economic life.
- Develop state-mandated SMET education exit standards that must be met by each sub-division of the state. Standards should exist primarily, but not exclusively, at the secondary level. Targeted funding should be allocated to encourage the implementation of state standards.

- ❖ Remove negative policies and procedures for acquisitions of equipment and supplies.
- ❖ Understand the role of SMET principles and career programs in economic development and global competition.
- ❖ Eliminate outdated certification codes that prohibit community college teachers and K–12 teachers from cross teaching.

Federal

- ❖ Establish incentives for the states and local governments to redesign their SMET for K–16.
- ❖ Provide flexible funding directly to the state/local level.
- ❖ Provide technical assistance to state and local entities needing support in creating program models and in identifying funding sources.
- ❖ Provide increased funding for SMET education at two-year colleges.

Assure cooperation between community college and industry to support continuous employment.

OFFICE OF THE PRESIDENT

- Use the U.S. Department of Education's community college liaison office, the NSF community college liaison office, other government offices sensitive to the role community colleges play in SMET, as well as the national community college organizations to help shape federal policies around the SMET principles.
- Establish and frequently articulate the importance of SMET education for the domestic and international security and well-being of the United States. Give greater visibility to the Office of Science and Technology Policy.

CONGRESS

- Provide enhanced financial support to individuals pursuing SMET education.
- Identify and provide additional funding to institutions that attain excellence in SMET education.

EDUCATION AND PROFESSIONAL BOARDS AND SOCIETIES

- Base evaluation/accreditation on the outcomes expected and on whether or not ***all*** students are involved in basic, general courses in SMET.
- Provide flexible ways to receive course credit through competency tests.

Regional Accrediting Boards

- ❖ Establish regional accrediting standards for SMET education for both academic and occupational programs.

Professional Societies

- ❖ Obtain endorsement for voluntary or mandatory credentials based on national standards for SMET occupations.
- ❖ Establish and support student chapters of the professional societies and invite interested students to attend meetings of the societies.
- ❖ Publish and distribute information that aids students to make career path decisions.

Licensing and Registration Boards

- Obtain endorsement for job standards based upon SMET competencies.

Program-Specific Accrediting Boards

- Establish more specific criteria for program development and administration with more frequent monitoring.
- Increase interaction between accrediting boards and SMET stakeholders.
- Obtain endorsement for national standards based upon SMET competencies.
- Require SMET instruction as part of the curricula.
- Involve program-specific advisory boards to help adopt particular standards that include SMET principles and work with college presidents and related professional associations for these purposes; encourage the participation of regional accrediting boards also.
- Work with the National Skills Standards Board to establish competencies for SMET education at the community college level.

Work with the National Skills Standards Board to establish competencies for SMET education at the community college level.

WHAT MATHEMATICAL COMPETENCIES DO EMPLOYERS WANT AND HOW TO GET THEM

Arnold Packer, Chairman, SCANS/2000, Johns Hopkins University, Institute for Policy Studies, Baltimore, Maryland

Education, including math and science education, will have to become more customer driven. In this respect, education is not unlike every other part of the contemporary American economy. There is, however, one big difference. Unlike the rest of the economy, education's customer is elusive. It often appears as if higher education, and especially the engineering schools, represents the customer for much of today's math education. The most important mathematical functions seem to be the trigonometric ones, perhaps a vestige of a time when surveying was a likely outcome for the mathematically talented.

The overriding goal, for many secondary schools and community colleges seems to be producing students who understand the calculus of trigonometric functions. While some teachers may talk about calculus concepts for understanding ideas such as rates of change, these concepts are rarely "on the test." Good grades are more likely to depend on remembering some clever transformation that can be promptly forgotten after graduation. (See E. S. Ferguson's book "*Engineering and the*

Mind's Eye" for a telling criticism of engineering education that emphasizes esoteric analysis at the expense of expertise in design and other practical problem solving.[1])

Some suggest that employers are the ultimate customer. Peter Drucker has a view that may be closer to the mark. Drucker says that "*The result of a school is a student who has learned something and put it to work ten years later.*"[2] Higher education, with an eye on alumni contributions should feel very comfortable with this "virtual customer—not the youth sitting in the lecture hall but the imagined successful adult ten years and more later". What mathematics does that customer require?

THE JOB MARKET'S DEMAND FOR MATHEMATICAL COMPETENCY

What mathematics do employers want? The Secretary's Commission on Achieving Necessary Skills (SCANS) asked employees and supervisors to rank 17 foundation skills for 35 entry-level jobs. (See Table 1.) Mathematics came in dead last. Arithmetic came in 13th. Surely, the relative ranking would increase as the level, pay, and complexity of the jobs increased. If employers were asked about the mathematics needed by their chief engineer or senior scientist, they would give a different answer. The answer to how much math is needed depends on how the question is asked.

The current methodologies for determining what math skills (or any other skill) are needed for any particular job usually includes an analysis of *frequency* and *criticality* (sometimes called importance). How often does the need for the skill arise and how much is at stake if it is missing? The SCANS re-

searchers applied this methodology to the 35 jobs that led to math's last place finish mentioned above. How might this methodology be expressed mathematically? The importance of any skill in a particular job is some function of the probability of it being used, weighed by its criticality in performing the task. Taking this formulation across jobs for any particular student, the market demand (MD) for any skill is a function of the probability of having any job(P) multiplied by the frequency of it being used, weighed by its criticality (C) and the economic importance of the task (E). That is, (1) MD=f(P,F,C,E).

Although we do not have the supporting data to estimate this equation statistically, the mathematical reasoning alone should guide our thinking about the math competencies needed for the marketplace. We can then compare the demand to the math being taught in the current curriculum. The comparison will show which competencies are overemphasized and which ones need more work.

MATH COMPETENCIES IN OVERSUPPLY

Table 2 lists some jobs for which math is likely to be important and their proportion of the labor force as well as some jobs that are likely not to need much math. Jobs that require a lot of math represent a small fraction of the labor force. That is, P is relatively small for many higher order math skills.

Economists, mathematicians, physicists, and astronomers combined only account for 80,000 jobs. Add 1.5 million engineers, one million accountants and a half-dozen other high-math content jobs and the total is less than five million slots in a labor force of about 125 million. Indeed, the total of all 4.74

million high-math content jobs is slightly less than the 4.75 million employed as retail sales workers, only one of the selected low-math content jobs.

But what about the math for more common jobs? Newspaper stories abound about the increasing need for math in all jobs. The Business Section of the Sunday *NY Times* of April 21,1996, had an interesting article on the resurgence of hiring in the automobile industry. The article emphasized the attractiveness of the jobs—paying over $30,000 annually and carrying full benefits. These incomes range up to $70,000 with overtime. It also emphasized the new requirements. "*This Hiring Spree Is Rewarding Brains, Not Brawn*" was the sub-headline. "*At one point we were hiring hands and arms and legs, and now we are hiring total people—with minds more important than the other,*" said Robert Eaton, Chairman and Chief Executive of Chrysler. HR Strategies Inc. is screening candidates for reading, math, spatial relations, manual dexterity and spatial reasoning.

The auto industry is not looking for higher mathematics. The ability to reason mathematically, understand percentages, and read graphs will suffice. How representative is the auto worker of jobs in the U.S. economy? Is the auto story just an anecdote or does it tell something about the nation's math requirements? American College Testing (ACT) is providing one good answer to the question. ACT's *National Job Task Analysis* project is determining Generalized Work Behaviors (GWBs) across the economy. Their initial sample of 3000 employees is intended to represent 80% of the nation's jobs. In ACT's preliminary list of the 25 most important GWBs, mathematics does not make the top 25. Even arithmetic is only in the #14 slot.

An earlier ACT analysis directly examined the need for *applied mathematics.* This ACT sample of 583 jobs included technical jobs (65% of the sample) and careers in science (7% of the sample of which 6% are engineers and related technologies). ACT's researchers divided the math skills into seven levels. Over 90% of the jobs profiled would be satisfied with math level 6 or less. Level 6 requires " . . . using negative numbers, ratios, percentages, and mixed numbers . . . calculate multiple rates, find areas of rectangles and circles, volumes of rectangular solids, solve problems involving production rates and pricing schemes." Enough algebra would be required to look up formulas or even transpose a formula before calculating. Only 18% of the jobs profiled needed level 6.

About 8% of the jobs require level 7. Even this bar was not too high. Level 7 requires the ability to calculate the volumes of spheres, cylinders, and cones, solve nonlinear equations, apply basic statistical concepts and locate errors in multiple-step calculations. Calculus, vectors, and even serious trigonometry was not mentioned. These more advanced competencies are over represented in the math curriculum relative to the demands of today's market.

In addition to ACT, the American Institute for Research (AIR) is developing a data base on jobs in the U.S. economy. The AIR effort will support a job data bank entitled O*NET which will be pilot tested in 1997. During the development of this bank, AIR has examined a small number of jobs (40) by surveys of employees. These jobs represent about 35% of U.S. jobs. AIR also had analysts examine a large number of jobs (1100). Both analyses asked about the math competencies required. One question asked how important mathematics was to job performance

on a scale of one to five. The analysts were also asked to determine the level of mathematics required. Seven levels were defined with "anchor" points to separate them. Data from AIR is expected soon, but the researchers do not anticipate answers that differ dramatically with ACT on the question of math requirements.

The SCANS, ACT, and AIR analyses provide consistent answers to the question of what math is needed on the job. Insofar as their careers are concerned, over 90% of students would hardly ever notice it if they never went further than fairly simple geometry and a modest course in algebra. A small amount of solid geometry, somewhat more advanced algebra, and some statistics would suffice for most of the remaining 10%. Taking integrals or differentiating equations are primarily needed for teaching college math and for a smattering of advanced engineering or scientific jobs. Today's extraordinarily high unemployment rate for PhD mathematicians means that the supply exceeds demand. Compare these facts with the National Council of Teachers of Mathematics proposed standards for grades 9 to 12 that include such "basics" as *trapezoidal estimates of the area under a curve.* (p. 148 in NCTM).[3]

MATH COMPETENCIES THAT ARE UNDERSUPPLIED

Despite these findings that most jobs do not require higher (more than algebra 2) mathematics, many math skills are undersupplied relative to today's job market demands. Only 9% of ACT's sample of 125,000 examinees tested at level 6; yet, ACT's job profiles showed that 18% of jobs require a level 6. Only 2% of the examinees tested at level 7; yet, 8% of the jobs require a level 7.[4] That is, there is

an undersupply of 9% and 6% at levels 6 and 7 respectively. According to ACT about half the jobs (47%) required level 5 or better, but only about a third (34%) of the examinees were that competent. What is level 5? The ability to look up and calculate within systems of measurements (e.g., converting form ounces to pounds) or between systems (from centimeters to inches) or calculate with mixed units (hours and minutes). The examinee must determine what information, calculations, and unit calculations are needed.

Some years ago, a similar analysis using U.S. Department of Labor (DoL) and Educational Testing Service (ETS) data produced comparable results.[5] The biggest gap between job requirements was at DoL level 4: "Perform arithmetic, algebraic, and geometric procedures in standard, practical applications, such as shop math and accounting". Jobs requiring more advanced mathematical and statistical techniques accounted for less than 10% of the total.

In addition to these broad industry-wide studies, the U.S. Departments of Labor and Education have been supporting 22 industries as they develop voluntary skill standards over the last three years. Recent legislation has established a National Skills Standards Board (NSSB) to bring these efforts together in a national system. In the meantime, however, we have preliminary results for a number of industries and jobs. High volume industries like retailing, hospitality and health care have modest requirements that primarily emphasize arithmetic. Some of the more technical jobs such as Electronic Technicians, Advanced Manufacturing, and CADD (Computer Aided Drafting and Design) require basic algebra, geometry and, in some cases, trigonometry. The demands are modest. The standards for

trigonometry, for example, require the ability to identify and use a calculator to compute cosine, sine and tangent. None of the more esoteric trig functions (or any other functions for that matter) or calculus are mentioned.

These findings about what math competencies are undersupplied are consistent with data on wage rates. A recent study focussed on the question of the growing importance of basic mathematics.[6] It asked: "Does mastery of basic math by individuals graduating from high school in 1980 play a larger role in determining their wages at age 24 than it did for individuals graduating in 1972?" It finds the skills needed are the "ability to follow directions, manipulate fractions and decimals, and interpret line graphs." The authors conclude that "a high school senior's mastery of skills taught in American schools no later than the eighth grade is an increasingly important determinant of subsequent wages." Indeed, the premium placed on good basic math skills for high school graduates who did not go to college doubled over the eight years (from 22 cents to 53 cents per hour for males and from 39 cents to 74 cents for women).

In conclusion, the implicit mathematics goal in today's curriculum of trigonometry and calculus is unnecessary for the vast majority of American workers. At the same time, the mathematical achievement of most American graduates is inadequate. Math educators need to approach the question of what mathematics to teach in a different way.

AN ALTERNATIVE APPROACH

Clearly, the analysis up to this point is rather discouraging for those of us who believe in a rigorous mathematics education. What, however, if the criterion was not: What math **is** being used on the job? But, instead, What mathematics **should be** used and how? Henry Pollak's list of employer expectations is a good place to start.[7] High-performance employers want to hire men and women who:

- are able to set up *problems*,
- know a variety of techniques that apply to *problems*,
- understand the mathematical features of *problems*,
- work with others on *problems*,
- see how to apply mathematical ideas to *problems*,
- are prepared for open unstructured *problems*, and
- believe in the use and value of mathematics in *problem* solving.

Pollak's formulation leads to the conclusion that employers are less concerned with the "mathematics" their employees can do than with the problems they can solve. Employees prepared in this manner can help high-performance firms throughout the nation who are re-engineering or restructuring to become more competitive. Irrespective of the buzzwords used, this change process means more analytical work, decision-making, and problem-solving by so-called "front-line" workers. The relevant questions are what is being analyzed, what decisions are being made and what problems are being solved.

The SCANS commission concluded that graduates who can solve SCANS-type problems within the specific domains of their industry will be prepared for the 21st century. They identified five categories of such problems:

1. **Planning and resource allocation decisions,** such as scheduling, budgeting and allocating space and staff.
2. Analyzing, evaluating, organizing and communicating **information**, including using computers for these purposes.
3. **Working on teams,** negotiating, teaching and customer service.
4. Using and making decisions regarding **technology.**
5. Understanding, monitoring, and improving **systems**.

Consider math curricula that meet the following criteria:

1. **Courses meet the general goals established in the NCTM standards.** Students learn to value mathematics, become confident in their own ability and become mathematical problem solvers. They are able to communicate mathematically and reason mathematically.
2. **All students are required to take enough math** to qualify for a predetermined share of the jobs in the economy and given the choice of going further. For example, if every high school student must take two years of math—geometry and algebra II—they should be brought to a level sufficient to qualify for 75% of the jobs. If they choose to take three years of math, they should have the math needed for 90% of

the jobs in the U.S. economy. (Obviously these are arbitrary cutoffs.)

3. **Mathematically-inclined individuals are able to go as far as they want** in these domains. Note that scheduling, systems, and information problems may appear as part of the math curriculum at levels as high as the PhD. In other words, there should be **no tracking;** students should be required to go along a single track until they meet the minimum qualifications (see para. 2) and permitted to continue if they elect to do so.

4. **Math courses are organized around problems in the five SCANS competency domains** instead of around techniques. That is, the algebra and geometry courses (if they must remain separate) should be organized around planning, information, and systems problems instead of around factoring polynomials or proving theorems.

A (SCANS) Problem-based Mathematics Competency

What would a problem-based curriculum look like? In a sense, all of today's mathematics courses teach their students to solve a set of problems: simple addition, long division, taking square roots, factoring a polynomial, proving triangles congruent and so on. Here are five randomly selected problems listed in the NCTM material[8]:

Find five examples of numbers that have exactly three factors (p. 93)

Approximate the area of the region under the curve $Y=2^x$ above the x axis and between the lines $x=1$ and $x=3$. (p. 148)

Find the roots of the equation $5x^3 - 12x^2 - 16x + 8 = 0$ (p. 152)

Suppose a Ferris wheel with a radius of 25 feet makes a complete revolution in 12 seconds. Develop a mathematical model relating the height of a rider to time. (p. 184).

Investigate limiting processes by examining infinite sequences (p180).

None of these problems which, by the way, NCTM suggests are to be solved by ***all*** students including the non-college bound, seem to be related to the requirements described by SCANS, ACT, AIR, DoL, or the industry standards. That is, the problems are not related to employer requirements. Consider the following alternative approach to math as practiced in a current NSF-funded project. The project involves five community colleges and the Johns Hopkins University. The goal is to introduce problem-solving into a math course that traditionally teaches linear algebra and provides an introduction to linear programming.

Manufacturing applications provide the impetus for the five CD-ROM-based modules that will be produced for the project. In the math module, students face the generic problem of allocating financial resources to maximize the profit for a new product. In this case, the new product is an electric car. The decision focus is on the advertising budget although the students—working in groups—have to budget for R&D, labor, materials, and new production equipment. Each of four groups has one version of the car to consider. The versions vary with the engine type (all electric or hybrid with a gasoline motor) and chassis (newly designed or retrofit). Students have to read charts, interpret marketing data,

express relationships in linear equations and use them in a spreadsheet, and understand how to use inequalities and linear programming to maximize profit. At the end of the module they report back (communicate mathematically) and engage in a group decision-making process leading to the selection of one of the four designs.

The impetus for this module is a set of real world problems identified by industry. Representatives of Boeing, the Alliance (among AT&T and the unions that represent its workers), Ford, and the National Association of Manufacturers helped identify SCANS-type problems that they expect an Associate Degree holder to solve. The module is designed to be part of (about 20%), rather than displace, the traditional math course. In a sense, the CD-ROM provides the class with a case study, delivered electronically.

The electric car CD-ROM can be used in a number of math courses. For that matter, the module can be used in other classes, from a design perspective, where the focus might be on engine design to marketing. Students would then connect mathematics to other courses as called for by NCTM. A well-regarded mathematician, Dr. Ivar Stakgold, is part of the team. Dr. Stakgold's role is to insure that the math is rigorous enough to transfer to four year colleges.[9]

This NSF project will produce four other CD-ROM-based modules. These other modules are designed for science and communication courses. Some modules will also be appropriate for use in math. One module for example, dealing with **systems**, will introduce the concepts of statistical process control and the statistics needed to use this technique. Another, also dealing with **systems,** requires

that students examine the broader environmental and social system that constrains plant locations and design decisions. In this latter case, the physics course is home for the module. The math could get quite advanced as students are required to comprehend the physics of plumes emitting from smokestacks.

The point of all of this is to follow Pollak's admonition to have students set up, solve, and present solutions to open-ended problems. It also meets the goals set out by NCTM. It reconciles the current practice of U.S. (but not European) math education to have courses with names that refer to broadly defined math techniques such as algebra, geometry, and trigonometry with employers' desire to talk about competencies in work-based terms. Curricula developers may ponder whether learning *perimeter = length x width* is an algebra or geometry problem. Employers would rather know whether their workers can allocate space in an efficient manner. Of course, solving the allocation problem may very well require knowing the equation for the perimeter. By using employers' language, rather than that of academics, educators may change the current situation in which employers pay little attention to school transcripts.

A similar "start with the SCANS problem" strategy is being employed in a second Johns Hopkins University project. In this project, Hopkins was funded by the Department of Education to work with Baltimore City high schools rather than community colleges. In this instance, the occupational arena is not limited to manufacturing. Math, science, and English teachers will soon begin to choose the problems upon which the electronic case studies will be developed. Health, tourism, retailing, and the built-environment may be selected. Students, for example,

may be asked to do a budget analysis for a new physical therapy service and develop a schedule for bringing it on line; thereby learning how to **plan and allocate resources**. Or they may be asked to design, budget and schedule the construction of a retail store, combining the retail and built-environment fields. In the latter case, they may have to understand and design the **system** of traffic flow to yield a target rate of revenue. Students will have to communicate about their mathematical findings (an **information competency**) when presenting their results. Moreover, the students work in **teams** to solve the problems, obviously learning **teamwork** skills.

The strategy is based on the following criteria:

1. The mathematical techniques are found while searching for a solution to a work-related problem. This reverses the usual situation wherein "applications" are an after thought, designed to illustrate a mathematical technique, appearing at the end of the chapter and clearly artificially constructed.
2. The problems often take some time to solve, can be solved in groups and the results can be presented to the class. This, in contrast to the math problem that can be solved in ten to twenty minutes for a solo math test.
3. The problem solution calls on math in an authentic way; yet, the math is rigorous enough to satisfy college entrance requirements.
4. The work-related problem meets a market demand. The problem is important to a wide variety of jobs. At a minimum, the student might expect to have a one-in-a-hundred chance of encountering a problem of this type.

SCANS-TYPE PROBLEMS AND GENERALIZED WORK BEHAVIORS

Table 3 associates the 25 most common generalized work behaviors (GWB) as found by ACT with the SCANS competency or foundation skill needed to carry out the behavior successfully. Where is the math? The following are only a few of the possibilities for teaching the math that jobs require. (The bold capitalized words are from SCANS and the bold lowercase words are paraphrases of the GWBs from the table.)

1. **PLANNING AND ALLOCATING RESOURCES: Scheduling oneself and setting priorities of work activities**. In some cases, this would only require simple arithmetic. In other situations, the solution could demand algebra. It could require creating GANTT diagrams, or PERT charts for activities that could be performed in parallel, or even probabilities for activities whose completion times are uncertain.

2. **INTERPERSONAL: Listen to the concerns/instructions of clients/customers or supervisors/co-workers and respond. Take customer orders for equipment/ machinery, materials, or services.** (In some situations this might require the ability to estimate). Concern such as: "About what would it cost to have a birthday party for 12 at this restaurant?" or instructions to "Give me enough paint to cover the kitchen with two coats" would require that skill.

3. **INFORMATION: Provide information to people, use a computer to process or communicate information.** This may require understanding enough algebra to feed formulas into a spreadsheet program so that a

detailed budget or invoice can be prepared for a dinner for twelve or a construction job.

4. **SYSTEMS: Manage the activities or resources of an organization or facility. Monitor work processes or operations. Monitor the activities or attitudes of clients/customers. Safeguard information, money, valuables, buildings/property, or people.** These functions may require statistics to create a survey or apply the concepts of statistical quality control or to develop and present quantitative data in tabular and graphical form with enough surrounding prose to make the story intelligible. It may also require developing a model of a process or activity.

5. **TECHNOLOGY: Operate individual pieces of equipment/machinery including computerized equipment other than a personal computer**. This may require reading gauges and enough math to determine when a piece of equipment needs to have its oil changed or other maintenance performed. Or it could require comparing operating characteristics to information provided in tabular or graphical form.

CONCLUSION

The math required for the workplace will surely change over the years. A generation ago few workers needed to know about statistical quality control or computers. The ACT and AIR research is not yet complete and the nation is just beginning to develop industry skill standards. Although the SCANS commission likes to think that most of their competencies will endure—especially the broad requirements for planning, systems, using information, technology, and interpersonal skills—surprises are inevitable.

Irrespective of the pace or extent of change, however, there are certain concepts that should shape mathematics education. Math education should develop competencies to solve problems that are frequently found in the workplace, not to train 100% of our students for the minuscule percentage of jobs held by professional mathematicians. Yes, there are uses for math other than in the workplace. Math aesthetics is one, but on this terrain math needs to compete—as an elective—with fine arts, philosophy, and music. Good citizenship requires math; but statistics easily out pace trigonometry or calculus as the math needed.

Mathematics courses should provide the math skills to solve problems on the job. One possible standard is that two years of high school math equip students for 75% of the jobs and three years for 90%. This criterion needs more study, but defining math standards in these terms is sensible. In this new competitive age, math education must provide students with what the job market demands—the ability to solve common and important problems.

REFERENCES

[1] Cambridge, MIT Press, 1992

[2] *The New Realities* (New York: Harper and Row, 1989)

[3] Curriculum and Evaluation Standards for School Mathematics, NCTM March, 1989

[4] Job Skill Comparison Charts, ACT, January 1996, p. 7

[5] A. H. Packer, *Preparing for Work in the Next Century*, The Hudson Institute, Indianapolis, May 1990

[6] *NBER Working Paper No. 5076*, The Growing Importance of Cognitive Skills in Wage Determination, Murnane, et al, The NBER Digest, October 1995.

[7] NCTM

[8] NCTM

[9] Prof. Stakgold was chair of the Math Department at the University of Delaware and Chair of SIAM (Society for Industrial and Applied Mathematics).

TABLE 2: PROPORTION OF SELECTED JOBS IN THE LABOR FORCE

Occupation	Employment (000s)	Employment (%)
SELECTED HIGH-MATH CONTENT JOBS		
Engineers	1,519	1.3
Accountants/Auditors	985	0.8
Financial Managers	701	0.6
Computer Programmers	565	0.5
Computer System Analysts	463	0.4
Clinical Laboratory Technicians	258	0.2
Pharmacists	169	0.1
Economists	37	0.3
Mathematicians	22	0.2
Physicists/Astronomers	20	0.2
Total Selected High-math content Jobs	4,739	4.0
SELECTED LOW-MATH CONTENT JOBS		
Retail Sales Workers	4,754	4.0
Waiters/Waitresses/Bartenders	4,400	3.7
Secretaries	3,576	3.0
Chefs/Cooks	3,100	2.6
Janitors	3,000	2.6
Office Clerks	2,737	2.3
Truck Drivers	2,700	2.3
Cashiers	2,633	2.2
Total Selected Low-math content Jobs	26,900	22.9

Source: **Occupational Outlook Handbook,** *1992–93 edition. U.S. Department of Labor. Total Employment in 1992 was 117.6 million.*

TABLE 3: SCANS COMPETENCIES REQUIRED FOR GENERALIZED WORK BEHAVIORS

Source: ACT unpublished data

SCANS COMPETENCIES AND FOUNDATION	25 TOP WORK BEHAVIORS*
1. **Planning and allocating resources** such as scheduling and budgeting and allocating space and staff.	4. Schedule work activities for oneself. 6. Determine the priority of work activities. 15. List things that need to be done or remembered for work.
2. Analyzing, evaluating, organizing and communicating **information**, including using computers for these purposes.	2. Use a computer to locate, process, or communicate information. 5. Provide information to people who ask specific questions or have specific concerns. 8. Prepare paperwork necessary for a work activity. 16. Check documents for completeness and quality of appearance. 17. Judge the importance, quality, and accuracy of information. 20. Enter information or data into computer files. 21. Read forms, work orders, requests, or instructions to determine what work needs to be done. 23. Use hand signals or short vocal instructions to control a work operation.
3. **Working on teams**, negotiating, leading, teaching, serving customers.	1. Listen to the concerns of clients/customers and respond. 11. Work with people in other departments to accomplish work. 13. Keep order/discipline among groups of people. 18. Take customer orders for equipment/ machinery, materials, or services. 22. Coordinate own work activities with the activities of others. 25. Listen to instructions from or concern of supervisors or co-workers and respond.
4. Using and making decisions regarding **technology**	9. Operate individual pieces of equipment/ machinery. 24. Operate computerized equipment other than a personal computer.
5. Understanding, monitoring, and improving **systems**.	3. Safeguard information, money, valuables, buildings/property, or people. 7. Manage the activities or resources of a department, business, organization, or facility. 10. Monitor the health condition of people. 12. Monitor the activities or attitudes of clients/ customers to make sure they are satisfied. 19. Monitor work processes or operations to make sure there are no problems.
6. Basic Skills - Arithmetic and mathematics	14. Perform arithmetic (addition, subtraction, multiplication, and division) as part of work activities.

INTERDEPENDENCE THROUGH PARTNERSHIPS: TRANSFORMING EDUCATION

Submitted to the National Science Foundation Roundtable, June 7, 1996, by Madison Area Technical College, Dr. Beverly S. Simone, President. This paper is the result of contributions from an array of staff and faculty directly involved in the respective initiatives identified within the paper.

INTRODUCTION

Madison Area Technical College (MATC) has a rich history in providing math, science and technology curricula as a foundation for its delivery of vocational, technical and adult education. As part of the Wisconsin Technical College System, MATC has a responsibility and need to work closely with business and industry to prepare people for the world of work, to upgrade the skills of those already in the workforce, and to fill the gap between what is learned in K–12 and what is expected by business and industry. This need has increased dramatically as technology demands a more knowledgeable and skilled workforce. The Wisconsin system is characterized by a strong response to the education and employment needs of the local district formalized in a local governing board which includes designated seats for employer and employee members. The nature of the instructional programming at MATC requires partnerships with business and industry. Each occupational program has an advisory committee with employer and em-

ployee members that helps develop the program's strategic goals, and review curricula, equipment and facilities.

As the need for a skilled workforce, competent in science and math, has dramatically increased, partnerships reflecting interdependence have become increasingly important both outside and within the college. These same workforce needs require dynamic curricular change and faculty development which cut across traditional disciplinary boundaries. MATC supports a number of initiatives for integrating science, math and technology to facilitate lifelong learning. While partnerships have developed around unique initiatives, there is increasing need for integration between and among the respective partners to achieve systemic institutional reform.

EXTERNAL PARTNERSHIPS

The concept of partnerships evokes a variety of models used by academic institutions to build and maintain interactions with business and industry. These partnerships are critical if the graduates of a technical program are to become credible employees in business and industry. The depth of the partnership within individual programs is further enhanced as individual companies or consortia of businesses and industries seek to expand and upgrade their employees or seek new training at the college to meet industry needs. MATCs' needs surround curriculum development, program formation and evaluation, and enhancement of student learning.

MATC Program and Curricula Development. MATC program development is structured around a set of state guidelines designed to confirm the need for a new technical or occupational program. The

state guidelines seek answers to the past history and the predicted future for occupational trends including expected skills and competencies of entry level workers, expected income, job growth, etc. New programs are scrutinized to insure that local, state and regional trends will support such instructional needs. For example, MATC offers unique associate degree programs in electron microscopy and biotechnology. The curriculum and equipment needs of the programs were defined through the input of business and industry partners via *ad hoc* program development committees. The *ad hoc* committees are the foundation for the program advisory committees previously discussed. The Biotechnology Lab Technician (BLT) program was developed in partnership with biotechnology companies and research facilities. The first DACUM (***D***evelop ***A Cu***rriculu***m***) at MATC was conducted as part of the development of the Biotechnology Laboratory Technician program; the first industry partners projected the curriculum needs, recommended equipment and recruited students.

Student internships and employment of graduates provide a strong link to many businesses. This is particularly true for biotechnology companies. Thirty-three of MATC's 93 programs have dedicated internships, work experiences or clinical affiliations which place program students directly in the job setting. MATC can support biotechnology companies by offering continuing education courses to the partners. Contract training and workshops in new technologies and techniques have been offered to researchers employed in these companies. Students enrolled in the Biotechnology Laboratory Technician program may participate in internships at University of Wisconsin-Madison research laboratories. Some of the internships have connected students to faculty who have encouraged the students to com-

plete their undergraduate degrees or continue with their research projects in university laboratories. For example, the Research Techniques class partnered MATC students with UW-Madison researchers in a consortium project evaluating enzymes produced by the Shiitaake mushroom. MATC students participated in basic long term research that was passed from student to student. This partnership between MATC students and the university promotes the credibility of MATC students' abilities and enhances students' transfer to the university. The skills and understanding demonstrated by the students in their internships and research projects allow individual faculty at the university to become acquainted with the depth of the curriculum in the Biotechnology Laboratory Technician program. The projects undertaken by students as part of their curriculum often lead to or strengthen other business and industry links.

Students in the Electron Microscopy (EM) program enroll in a 2-credit special projects course. The course links the EM student to a business or industry problem. Sometimes these are projects or activities outside the company's primary scope, but offer the student an opportunity to engage in real problem solving. In the past few years, EM students have worked with Johnson's Wax, John Deere, and the Plasma Research Center at UW-Madison to study problems associated with structural failures, mode of action of insecticides, and electron beam-plasma interactions. The project at the Plasma Research Center not only connected EM students to UW-Madison faculty and students, but also provided an opportunity for new internships for Machine Tool students in modifying the EM equipment.

Formalized partnerships with business and industry. In addition to the ongoing partnerships which support one- and two-year formal programming, MATC has entered into formal agreements between a business/industry sponsor and a program student. The business or industry partner agrees to provide an internship site and an on-site mentor for a student. These internships provide 1,000 to 1,200 hours of paid work-based learning for the student. Current MATC partnered programs include the Agricultural Equipment Technology program (John Deere Ag Tech) and the Diesel Equipment Technology program (Top Tech). The Chrysler Apprenticeship Program (CAP) and the Bioprocess Manufacturing Technician program are scheduled to begin in the 1996-97 academic year. These companies make an investment in their long-term viability by examining the resources needed to meet their long-term goals and preparing employees to fill their workforce needs.

John Deere. MATC and the John Deere Company have teamed up to provide an agriculture equipment technology program called John Deere Ag Tech, providing training specifically for the John Deere Company and its dealers. John Deere dealers sponsor students in the program who are then able to apply the skills learned directly on John Deere equipment. When John Deere Ag Tech students are off campus and fulfilling their internships at the company, the MATC labs and shops, equipped through donations by John Deere, are used for continuing education of other industry employees.

Top Tech. MATC's new associate degree Diesel Equipment Technology Program and a consortium of Wisconsin diesel industries created a partnership called Top Tech. Sponsoring companies offer students paid summer internships. The students work along-

side experienced diesel technologists, gain valuable on-the-job training and build their resumes while still in school. In addition, a consortium of industry representatives and MATC instructors shaped the program's curriculum to create highly skilled graduates who can eventually be groomed for supervisory positions. Top Tech focuses heavily on advanced computer and electronics training, diagnosing and troubleshooting abilities, communications and management skills. Demand for highly trained technologists far outweighs the supply of job applicants. By working together to develop Top Tech, MATC and diesel companies can assure program participants that they will be able to get good jobs when they graduate—and sponsoring companies can look forward to a pool of skilled, experienced employees.

Chrysler Automotive Program. The Zone Office of the Chrysler Corporation asked MATC to join in the development and operation of an educational program that will elevate the level of competency of Chrysler technicians through an associate degree offering in automotive technology. This offering parallels the current associate degree automotive technology program. A section of students partnered with a Chrysler dealer will start in the fall of 1996. The instruction will be based on quarters, rather than semesters, to accommodate student rotation between internship training at MATC and on-the-job experience. Chrysler Corporation provides MATC with a variety of vehicle models and repair manuals, software, on-line communication with Chrysler Corporation, and a vehicle which can be used for traveling to recruit students and visit internship sites.

Bioprocess Manufacturing Technical Program. The newly developed Bioprocess Manufacturing Technician Program is a partnership with a consor-

tium of companies engaged in fermentation and bioprocessing. The program will share similar courses and preparation with the Biotechnology Laboratory Technician (BLT) program, but include increased work-based internships. Students will be able to select programming leading to research "bench" positions or large scale production positions. Large scale manufacturing facilities are not easy to duplicate and are cost prohibitive to build. However, students need direct experience in large scale equipment use, coupled with academic course work, to build the competencies required in this technical area. This program is scheduled to begin in the fall of 1996.

The above partnerships are but a few of the ongoing partnerships with business and industry. These partnerships are mutually beneficial and enhance the learning environment for the student. MATC's partners have donated equipment, vehicles, printing resources, multimedia information, on-site downlinks, and electronic information connections. These are "things" that can be documented and inventoried. The benefits to MATC are faculty enhancement, networks to potential employers through internships and work experiences, and access to changing and advancing technologies. Less obvious are the gains of our business and industry partners. They gain access to: a pool of well-qualified job applicants, continuing education for their employees, shared equipment and new technologies, and technical assistance from college faculty and staff.

Expanding the partnerships: Biotechnology and Metrology/ISO 9001. MATC's Biotechnology Laboratory Technician program and its partners are in the second year of a National Science Foundation grant of one million dollars. The "Advanced

Biotechnology Education Partnership Program" (ABEPP) is a three year project designed to provide skilled employees for the biotechnology industry. This is yet another example of MATC's commitment to education/industry partnerships.

Up-to-date, easily-understood curricula are being developed by MATC, the UW-Madison Teacher Enhancement Program in Biology (TEPB) and the industry-based BioPharmaceutical Technology Center Institute (BTCI). Biotechnology is becoming an increasingly important industry in Wisconsin. High school science teachers realize the importance and are including an introduction to molecular biology in their curriculum. Equipment donations and matching funds from NSF have been effectively utilized as part of a growing "lending library." High school teachers borrow specialized equipment from this library to teach segments on recombinant DNA and other biotechnology-related science. Without opportunities to borrow this expensive and specialized equipment, most schools would not be able to offer laboratory activities in their biotechnology curriculum.

The ABEPP has coordinated several local and state initiatives. Activities to support high school and middle school students include hands-on laboratory activities for students and teachers at BTCI, MATC and UW-Madison. The outreach extends to "mobile" workshops conducted at the schools to avail larger groups of students. Saturday morning career exploration presentations by young scientists draw high school students interested in careers in math, science and engineering. Semester-long projects at BTCI with middle school students are designed to increase the science and applied math skills of these younger students. School-to-work activities for high school

students include the introduction to biotechnology courses articulated with MATC and the Youth Apprenticeship Program in Biotechnology.

Middle and high school teachers are encouraged to enroll in summer courses or school year workshops coordinated through UW-TEPB. These workshops provide a link to science content, research scientists, and networks among teachers.

Metrology/ISO 9001 Project. MATC's Machine Tool Program received a NSF grant to develop its "Advanced Dimensional Metrology and ISO 9001 Education Partnership Program." This unique collaborative effort also brings together educators and industry leaders: faculty from MATC, the Madison Metropolitan School District and the University of Wisconsin-Madison; the UW Center for Quality, four other community colleges in the U.S. and Canada; local and state public school agencies; and Ford Motor Company, Giddings & Lewis Machine Tool Company and other industries. The partnership was formed to provide the education and training in metrology and ISO 9001 for the engineering, manufacturing and service/installation industries. Metrology is critical to the success and competitiveness of business and industry and, although conceptually basic, it is often missing in formal educational programs. The teacher enhancement activities and mobile metrology laboratory will allow educational and business/industry partners to incorporate measurements and calibration in mathematics and science courses and applications.

In summary, partnership students benefit from being trained in the latest technologies and in using the latest equipment that MATC either cannot house or purchase. Students receive support for school ex-

penses from the business/industry partners through employment while going to school or tuition reimbursement. Students are also exposed to a potential job after graduation. Employers benefit from partnerships in several ways. Not the least of which is that they are given a preliminary look at future employees. As business and industries become involved in curriculum development and revision, MATC provides them with a source of employees who are trained in areas important to their particular industry and for an academic evaluation of potential or latest technology and equipment.

While it is logical and obvious to include internships and work experiences in technical programs, it is often difficult to include a work experience component in introductory math and science courses. *There is a need to support pilot programs across the country to experiment with models that identify incentives for employers to participate in work experience activities. Information gained from these pilots could be shared at a national conference. There is also the need to support the development of curricula that provides information about workplace applications for math and science.*

Partnerships with other higher education institutions. Curriculum and instruction in technical occupational programs at MATC are built on a technically and scientifically appropriate core. The content of program core courses must connect to and be supported by mathematics and science courses that build the foundation for the program students. Additionally the science and mathematics courses must be pedagogically sound. Partnerships between MATC and the University of Wisconsin system, particularly UW-Madison, are essential to instruction that is credible to employers and other academic institu-

tions. These partnerships include: articulation and transfer agreements enabling students to transfer to/from the UW-system; links to academic programs at UW-system campuses to provide internships and work experiences; and direct participation by MATC and UW faculty in multiple projects. Two NSF supported projects linking MATC to UW-Madison are systemic chemistry curriculum reform (Establishing New Traditions: Revitalizing the Curriculum) and the National Institute for Science Education (NISE).

Through the systemic chemistry curriculum reform partnership, an MATC faculty member is working with the Department of Chemistry at the UW-Madison to shift undergraduate chemistry curriculum from "faculty centered teaching to student centered learning." Sound undergraduate chemistry curriculum at the community college supports students transferring to 4-year institutions and supports the content of technical/occupational curricula. This collaboration of faculty from the community and 4-year college is necessary if the reform of the freshman chemistry experience is to be successful.

Community college faculty also participate in the National Institute of Science Education. A member of the MATC science department is participating in the project with emphasis on the freshman level science curriculum. Again, the issues of articulation and transferability of students completing technical college courses is predicated on sound instruction (and learning) in the introductory courses.

The community college partners in higher education reform projects need to work with other higher education institutions to assess and develop appropriate science and mathematics courses, especially

those introductory courses shared (or taught) by both. Partnerships such as those mentioned above should be expanded and reinforced.

Partnerships with K–12 systems. Science and mathematics preparation through the K–12 system is necessary for students entering technical programs. The articulation of MATC programs with school districts and the post-secondary options programs allow high school students to participate in technical programs while still in high school.

All MATC technical and occupational programs have identified basic science and mathematics preparation necessary for entry into a program The partnership with K–12 systems is necessary if students are to be successful. *Community college partners in science and mathematics reform projects need to communicate to the K–12 systems the level of competency and understanding needed for technical programs.*

INTERNAL PARTNERSHIPS

Professional development provided one of the earliest reasons for partnering. There was the recognized need for transforming the way that students were perceived, instruction delivered, curriculum designed and learning assessed. MATC's Critical Literacy Seminar was designed by faculty for faculty to achieve these ends. For one semester a heterogeneous group of 20 teachers are released from teaching one course to study, share, and create better learning experiences together. Participants are chosen to insure a cross-section of the college faculty. Topics such as lecture free classrooms, writing across the curriculum, authentic assessment, and adapting to various learning styles are examined

through supplementary readings with topical experts. During the second semester, each faculty member redesigns one course to achieve more student learning. Faculty routinely report much success with this program and stress the importance of the collaboration with other teachers. This seminar is in its sixth year. At this point, 120 teachers have completed it. Many of the speciality seminars have included faculty from surrounding K–12 schools, other technical colleges, and baccalaureate programs in the area.

Emanating from the Critical Literacy Seminar have been other seminars, courses, and in-service activities offered by teachers for teachers. Content areas include diversity, educational research and reform, assessment, teaching methods, and use of technology to name a few. Internal partnerships have coalesced as teachers have had the opportunity to collaborate in their individual learning.

Instructional Excellence Initiative. MATC has launched an institution-wide, cross-functional Instructional Excellence Initiative (IEI). Through the IEI, the college commits to nurturing a learning community that maximizes opportunities for student success by utilizing innovative instructional strategies and assessment, collaboration with other partners, and fostering experimentation and planning. No one department has sole responsibility for this initiative; it includes the College President and representation from Instruction, Human Resources (staff development), and Institutional Advancement (research, assessment, program evaluation). The development of the Instructional Excellence vision is interdisciplinary so that efforts throughout the college will be consistent and aligned. The assistance of partners in the K–12 system, the University, business and in-

dustry is vital for this vision to be realized and for systemic reform to occur. Current pilot activities funded by this initiative include:

- Production of videos to provide instruction on the use of electron microscopy for outreach users such as the university.
- Development of a non-lecture or lecture-lite classroom for the Introduction to Biotechnology course. The pilot will redesign the delivery method of the course to increase the student's active learning. Emphasis will be on the development of a cooperative learning environment where students take charge of their own learning program and further develop critical thinking skills.
- Development of a "capstone" course, "Bringing Sciences to the 21st Century", which shows the interconnectedness of science, society and the legal issues joining them. The course will be taught by a team of faculty to emphasize the interdisciplinary nature and incorporate collaborative learning strategies.
- Funding for a Technology Academy which provided the opportunity for teachers to spend three days learning to use various forms of technology for classroom strategies and management of learning environments.

The IEI addresses the need for "capacity building" in faculty for instructional skills needed to respond to rapidly changing technology and industry standards. The challenge is to provide opportunities and incentives for faculty to stay technologically current, to develop curricula for new technologies, and to explore and utilize new instructional methods to promote student success. *To promote the development and expansion of this type of institution-wide capacity building the following factors should be considered:*

1) *provide monetary support for equipment to produce materials for alternative instructional delivery (e.g. cd-rom, video);*

2) *provide support for the development of information technology which supports connectivity and access to information about instructional initiatives;*

3) *encourage the development of "Curriculum Development Teams" that include content experts, curriculum developers, writers, programmers, and multimedia experts;*

4) *encourage the development of "Curriculum Development Consortia" to set up shared centers for curriculum development with resident curriculum development teams who would work with faculty from consortia schools; and*

5) *provide support for a major faculty development initiative.*

Core Abilities Initiative. The MATC Core Abilities Initiative is an institution-wide effort aimed at curriculum transformation to facilitate the integration of general education methods and perspectives with science and technology. The desired outcome of this initiative is to ensure that general education skills essential to learning and functioning successfully in the community and employment are integrated across the curriculum. More specifically for those students whose academics focus on math, science and technology, the goal is to encourage the students to become aware of themselves from a variety of perspectives in the context of rapid technological change. At the same time, it is expected that the core abilities will help to ensure those students focusing their academics outside the realm of math, science and technology can integrate elements from these areas into their world view.

The core abilities are content-based rather than course-based. This means that collectively when students graduate from the institution they should have mastered each of the core abilities, regardless of the program. It is intended that no single course will necessarily correspond to any one core ability, nor are core abilities intended to be developed only in General Education courses; courses in occupational programs would also address these abilities. The goal is to have students continually exposed to these key learning areas in occupational courses, thereby consistently demonstrating the influences and importance of the core abilities in the applied setting of work. In this model, multiple perspectives of the core abilities are continually introduced and reinforced across general education and applied environments. The result is math/science integrated, coordinated instructional base setting the stage for lifelong learning. This model can be viewed as a "convergence model." It is the merging of sound instructional practices in general education with applied work settings to maximize student learning.

The eight core abilities identified by MATC faculty are: communications; critical thinking; ethics; global awareness; mathematics; self-awareness; science and technology; and social interaction. A matrix will be the primary mechanism for identifying these core abilities within courses and assessing the relationship in general education courses and relating and integrating them with program curricula. The matrix will direct attention to gaps, help staff coordinate curriculum to meet the needs of students, and improve course content and instruction. For each core ability, the matrix will provide greater definition by identifying particular indicators of student achievement. Specific achievement levels in each of

the ability areas will be determined by individual programs to ensure a match to the rigors of specific curricula. The goal is for all students to have the opportunity to make significant progress in the core abilities while achieving program objectives. The matrix helps to ensure the centrality of general education at MATC by integrating the core abilities throughout the curriculum, in a developmental and systematic manner.

This initiative is a process for developing curriculum and assessing student learning outcomes. As such, faculty representing all instructional divisions were provided release time to concentrate their efforts on this initiative. Their efforts laid the foundation for the Assessment Implementation Team which will pilot the use of the Institutional Core Abilities Outcomes Matrix during the 1996–97 academic year. Following the pilot, the challenge will be to integrate the system into the fabric of instruction, across all curricula. A three-year plan will be developed to build on standards for course, program and institutional levels of assessment. The core ability matrix will be shared with secondary schools to assist the schools with designing curriculum that addresses the core abilities and better prepares students for the world of work and postsecondary education.

This process for developing curriculum, integrating knowledge and competencies, and assessing student learning outcomes is time and labor intensive. However, as demonstrated by the accomplishments of this initiative to date, it can lead to significant and exponential change in a large, complex system.

There is a need to support and expand opportunities that provide for faculty interaction and involvement in the development of curriculum that integrates general education with science and technology.

Critical Literacy, Instructional Excellence and the Core Abilities Initiatives are designed to improve the learning of science, mathematics, engineering, and technology education by all students and result in programs that transcend traditional disciplinary boundaries. Integration of these initiatives into the institutional culture will provide a foundation which supports and advances the goals of science and technology programs. This integration will be enhanced as teachers develop and implement their individualized professional growth plans.

SUMMARY

Historically, MATC has filled a major gap for individuals and subsequent employers—it has filled the gap between what is learned in K–12 and what is expected on the job. For instance, an auto body technician may be able to learn many necessary skills for his or her job outside of a traditional classroom. But, auto repair today requires specialized knowledge of metals and paints and how they react to and with each other. To understand these reactions, knowledge of chemistry, physics and math is required. This level of learning cannot be learned on the job and is beyond what the K–12 system offers. MATC fills the gap through general education requirements built into its Auto Body Technician Program and similar programs. The challenge for MATC is to identify the necessary knowledge that transforms the gap into meaningful learning oppor-

tunities for students—without duplicating what is offered in K–12 or on the job. Program development partnerships with employers, such as the program advisory committees, and with the K–12 system help MATC meet this challenge.

As technology has advanced, the gap that MATC fills has increased. While the college has historically depended on partnerships with K–12, universities, and business and industry, this interdependence is now essential for survival. Teachers, administrators and the college as a whole need to develop new skills for collaborating. The college needs to support the individual risk takers who forge new and better developed relationships. In addition to supporting this entrepreneurial spirit, many challenges remain for the development of systems that allow colleges like MATC to better meet the needs that are emerging. Some of the questions needing to be addressed are:

- Are there internal systems for storing and sharing information that can facilitate effectiveness of partnering both inside and outside the college?
- Are there components (i.e. staff development activities, partnerships, models) basic to all colleges to integrate math and science competencies throughout the curriculum?
- Are there systemic ways for involving increasing numbers of faculty in partnering initiatives rather than relying on those who are risk takers?
- Are there competencies which are readily transferable from one partnership to another? Are they transferable to different organizations? If so, can they be readily taught?

NATIONAL SCIENCE FOUNDATION RESOURCES

National Science Foundation. (1995). *Foundation for the Future: Turning Points* (Report No. 95-36). Profiles individuals and the impact that programs of the Directorate for Education and Human Resources have made in their professional and personal lives. (Third in a series). Arlington, VA: Author.

National Science Foundation. (1994). *Foundation for the Future: The Systemic Cornerstone* (Report No. 94-121). Highlights of systemic reform activities and accomplishments of the Directorate for Education and Human Resources. (Second in a series). Arlington, VA: Author.

National Science Foundation. (1994). *Foundation for the Future.* (Report No. 94-65). Highlights of the accomplishments of the Directorate for Education and Human Resources in the reform of science, mathematics, engineering, and technology education. (First in a series). Arlington, VA: Author.

National Science Foundation. (1994). *Programs of the Directorate for Education and Human Resources.* (pamphlet, Report No. 94-77). Summary of the Directorate for Education and Human Resources programs and examples of funded projects. Arlington, VA: Author.

National Science Foundation. (1994). *Building the System: Making Science Education Work.* (Report No. 94-107). Proceedings of the second annual invitational conference on education reform. Arlington, VA: Author.

ELEMENTARY AND SECONDARY

National Science Foundation. (1995). *First National Conference on the Educational Application of geographic information Systems* (EdGIS). (Report No. 95-124). Conference report and recommendations on the application of geographic information systems to elementary and secondary education. Arlington, VA: Author.

UNDERGRADUATE

National Science Foundation. (1995). *Restructuring Engineering Education: A Focus on Change.* (Report No. 95-65). Report from a workshop on the reform of undergraduate engineering education. Arlington, VA: Author.

National Science Foundation. *Technical Education in 2-year Colleges* (HES 17). Report from a statistical study of science and engineering technology education in two-year institutions. Arlington, VA: Author.

National Science Foundation. (1994). *Innovation and Change in the Chemistry Curriculum.* (Report No. 94-19). Report from a workshop on the reform of the undergraduate chemistry curriculum. Arlington, VA: Author.

National Science Foundation. (1994). *Gaining the Competitive Edge: Critical Issues in Science and Engineering Technician Education.* (NSF 94-32). Report from a workshop on technical education sponsored by NSF and the Federal Coordinating Council for Science, Engineering, and Technology. Arlington, VA: Author.

National Science Foundation. (1993). *Learning and Technology in the Future: A National Science Foundation Workshop.* (Full Report, No. 95-15). Report from a workshop on the use of technology in education. Arlington, VA: Author.

National Science Foundation. (1995). *Short-Term Impact Study of the Presidential Awards for Excellence in Science and Mathematics Teaching.* (Report No. 95-51). Report from a short-Term evaluative study on the Presidential Awards program. Arlington, VA: Author.

National Science Foundation. (1995). *Short-Term Impact Study of the National Science Foundation's Young Scholars Program Report.* (Report No. 95-50). Report from a short-Term evaluative study of the Young Scholars program. Arlington, VA: Author.

National Science Foundation. (1995). *Footprints: Strategies for Non-Traditional Program Evaluation.* (NSF 95-41). Report from a conference on innovative ways to evaluate education programs. Arlington, VA: Author.

National Science Foundation. (1994). *Evaluation of the National Science Foundation's Statewide Systemic Initiatives Program: First Year Report.* (Report No. 94-95). Report of descriptive findings from the first year of the five-year evaluation of the Statewide Systemic Initiatives program. Arlington, VA: Author.

National Science Foundation. (1994). *Teacher Enhancement for Elementary and Secondary Science and Mathematics: Status, Issues, and Problems.* (Report No. 94-80). Discusses ways to improve teacher preparation and the quality of instruction through the provision of effective in-service education programs. Arlington, VA: Author.

National Science Foundation. (1994). *A Study of NSF Teacher Enhancement Program Participants and Principal Investigators: 1984–1989.* (Summary Report No. 94-57). Arlington, VA: Author.

National Science Foundation. (1994). *A Study of NSF Teacher Enhancement Program Participants and Principal Investigators: 1984–1989.* (Technical Report No. 94-58). Final Report of the evaluation of the Teacher Enhancement program. Arlington, VA: Author.

National Science Foundation. (1994). *The Visiting Professorships for quality Women Program: Lowering the Hurdles for Women in Science and Engineering.* (Report No. 94-88, NSF Summary and Comments). Brief summary of the findings of the evaluation of the Visiting Professorships for Women program. Arlington, VA: Author.

National Science Foundation. (1995). *The Visiting Professorships for Women Program: Lowering the Hurdles for Women in Science and Engineering Evaluation* (Report No. 93-159). Report of the Visiting Professorships for Women program. Arlington, VA: Author.

National Science Foundation. (1993). *Assessment of the National Science Foundation's 1988–90 Undergraduate Faculty Enhancement Program: Interpretive Overview* (NSF 93-123) Interpretive overview of the evaluation of the Undergraduate Faculty Enhancement program, written by the evaluation's advisory committee. Arlington, VA: Author.

National Science Foundation. (1993). *Assessment of the National Science Foundation's 1988–90 Undergraduate Faculty Enhancement Program: Executive Summary* (Report No. 93-122; Included in NSF 93-121). Brief summary of the findings of the evaluation of the Undergraduate Faculty Enhancement program. Arlington, VA: Author.

National Science Foundation. (1993). *Assessment of the National Science Foundation's 1988–90 Undergraduate Faculty Enhancement Program: Final Report* (Report No. 93-121; Includes NSF 93-122). Final report and executive summary of the evaluation of the Undergraduate Faculty Enhancement program. Arlington, VA: Author.

National Science Foundation. (1993). Proceedings of the NSF Workshop on the Role of Faculty from the Scientific report *Disciplines in the Undergraduate Education of Future Science and Mathematics Teachers.* (Report No. 93-108) Workshop proceedings that address themes considered to be of particular importance to the education of prospective elementary and secondary science' mathematics' end technology teachers. Arlington, VA: Author.

National Science Foundation. (1993). *Partners in Progress.* (Report No. 93-64). Report of a workshop on the role of professional societies in science' mathematics, engineering, and technology education in two-year colleges. Arlington, VA: Author.

GRADUATE AND POSTGRADUATE

National Science Foundation. (1996). *Graduate Education and Postdoctoral Training in the Mathematical and Physical Sciences.* (Report No. 96-21) Summary of a workshop sponsored by the Directorate for Mathematical and Physical Sciences in 1995. Arlington, VA: Author.

HUMAN RESOURCES DEVELOPMENT

National Science Foundation. (1993). *Eastern and Western Regional Conferences: "The Database Monitoring System: Making it Work".* (Report No. 93-78). Proceedings from two conferences on the Comprehensive Regional Centers for Minorities program. Arlington, VA: Author.

National Science Foundation. (1993). *Increasing the Visibility of Women in Science* (Report No. 93-144). Profiles of awardees of the Visiting Professorships for Women program and highlights from the program evaluation. Arlington, VA: Author.

National Science Foundation. (1995). *Diversity in the Scientific and Technological Workforce: 1994 Conference Proceedings.* (Report No. 95-3). Conference proceedings of the 3rd National Conference on Diversity in the Scientific and Technological Workforce. Arlington, VA: Author.

National Science Foundation. (1994). *Diversity in the Scientific and Technological Workforce: 1993 Conference Proceedings.* (Report No. 94-12). National Science Foundation. Conference proceedings of the 2nd National Conference on Diversity in the Scientific and Technological Workforce. Arlington, VA: Author.

RESEARCH, OUTCOMES AND OUTREACH

National Science Foundation. (1996). *Best Practice in Action.* (Report No. 96-202). A descriptive analysis of exemplary teacher enhancement institutes in science and technology. Arlington, VA: Author.

National Science Foundation. (1995). *Innovating and Evaluating Science Education: NSF Evaluation Forums 1992–94.* (Report No. 95-162). Papers presented at NSF on a variety of evaluation topics (e.g. curriculum assessment; systemic evaluation; education reform; social marketing). Arlington, VA: Author.

National Science Foundation. (1993). *User-Friendly Handbook for Project Evaluation.* (Report No. 93-152). Provides advice and guidance on how to evaluate an NSF-sponsored education project. Arlington, VA: Author.

National Science Foundation. (1993). *Learning and Technology in the Future: A National Science Foundation Workshop.* (Summary Report, No. 95-14). Report from a workshop on the use of technology in education. Arlington, VA: Author.

TO REQUEST PRINTED NSF PUBLICATIONS

- send e-mail request to: pubs@nsf.gov
- fax request to: 703-644-4278
- call request to: 703-306-1130 or Telephonic Device for the Deaf (TDD 703-306-0090)
- send written request to:

  NSF Forms and Publications Unit
  4201 Wilson Boulevard
  Room P-15
  Arlington, VA 22230

When making a request, please include the following information:

- NSF publication number,
- number of copies, and
- your complete mailing address.

OCCUPATIONAL SKILLS STANDARDS PROJECTS

Funded by the Departments of Education and Labor

Background: The 1990 Education Summit created six national education goals embraced by the President and the nation's governors intended to close America's skills and knowledge gaps. In 1991, the America 2000 strategy for achieving these goals was introduced, calling for business and labor "to adopt a strategy to establish job-related (and industry specific) skill standards built around core proficiencies and develop skill certificates to accompany these standards." In 1992 and 1993, to foster this process, the U.S. Departments of Labor and Education entered into cooperative agreements with 22 organizations representing a wide range of industries. Each group built a pilot project to demonstrate an approach to setting voluntary national skill standards and building wide spread industry acceptance of the standards. *(From National Skill Standards Board materials)*

ADVANCED HIGH-PERFORMANCE MANUFACTURING

National Coalition for Advanced Manufacturing (NACFAM)
C.J. Shroll
Director
1331 Pennsylvania Avenue NW
Suite 1410 North
Washington, DC 20004 - 1703
Tel: (202) 662-8968
Fax: (202) 662-8969
E-mail: cjshroll@aol.com

AGRICULTURAL BIOTECHNOLOGY

National FFA Foundation
Bernard Staller
P.O. Box 15160
Alexandria, VA 22309-0160
Tel: (703) 360-3600 ext. 268
Fax: (703) 360-5524
E-mail: natlffa@aol.com

AIR CONDITIONING, HEATING, AND REFRIGERATION

V-TECS, Southern Association of Colleges and Schools
Victor Harville
Project Director
1866 Southern Lane
Decatur, GA 30033-4097
Tel: (800) 248-7701
Fax: (404) 679-4556
E-mail: 74507.2026@compuserve.com

AUTOMOBILE, AUTOBODY, MEDIUM / HEAVY TRUCK TECHNICIAN

National Automotive Technicians Education Foundation (NATEF)
Patricia Lundquist
Executive Director
13505 Dulles Technology Drive, Suite 2
Herndon, VA 22071-3421
Tel: (703) 713-0100
Fax: (703) 713-0727

BIOSCIENCE

Education Development Center (EDC)
Judith Leff
Senior Project Director
55 Chapel Street
Newton, MA 02158
Tel: (617) 969-7100
Fax: (617) 332-4318
E-mail: judyl@edc.org

CHEMICAL PROCESS INDUSTRIES

American Chemical Society (ACS)
Kenneth Chapman
Head of Technicians Resources/Education
1155 16th Street, NW
Washington, DC 20036
Tel: (202) 872-8734
Fax: (202) 872-8068
E-mail: kmc97@acs.org

COMPUTER-AIDED DRAFTING AND DESIGN (CADD)

National Coalition for Advanced Manufacturing (NACFAM)
Jane Beardsworth
Project Director
1331 Pennsylvania Avenue, NW
Suite 1410 North
Washington, DC 20009-1703
Tel: (202)662-8960
Fax: (202)662-8964
E-mail: jbeardsw@bmpcoe.org
nacfam@explorer.clark.net

ELECTRICAL CONSTRUCTION

National Electrical Contractors Association (NECA)
Charles Kelly
Project Director
3 Bethesda Metro Center, Suite 1100
Bethesda, MD 20814-5372
Tel: (301) 657-3110
Fax: (301) 215-4500

ELECTRONICS

American Electronics Association (AEA)
Cheryl Fields Tyler
Vice President, Workforce Policy & Program
5201 Great America Parkway
P.O. Box 54990
Santa Clara, CA 95056
Tel: (800) 284-4232
Fax: (408) 970-8565
E-mail: cheryl_fields_tyler@aeanet.org

ELECTRONICS

Electronics Industries Foundation (EIF)
Irwin Kaplan
Project Director
919 18th Street, NW, Suite 900
Washington, DC 20006
Tel: (202) 955-5823
Fax: (202) 955-5837
E-mail: mmannon@aol.com

GROCERY

Grocers Research and Education Foundation (GREF)
Gail Hanger
Co-Director
1825 Samuel Morse Drive
Reston, VA 22090
Tel: (703) 437-5300
Fax: (703) 437-7768

HAZARDOUS MATERIALS MANAGEMENT TECHNOLOGY (HMMT)

Center for Occupational Research & Development (CORD) - Hazardous Materials
James Johnson
Project Director
601 Lake Air Drive
Waco, TX 76710
Tel: (817) 772-8756
Fax: (817) 772-8972
E-mail: jjohnson@cord.org

HEALTH CARE

Far West Laboratory for Educational Research and Development (FWL)
Vince Constabileo
730 Harrison Street
San Francisco, CA 94107-1242

Tel: (415) 241-2712
Fax: (415) 241-2702

HEAVY HIGHWAY/CONSTRUCTION & ENVIRONMENTAL REMEDIATION

Laborers-AGC Education and Training Fund
John Tippie
Associate Director for Western U.S. & Canada
27055 Ohio Avenue
P.O. Box 419
Kingston, WA 98356
Tel: (360) 297-4152
Fax: (360) 297-3368
E-mail: 71112.1275@compuserve.com

HOSPITALITY AND TOURISM

Council on Hotel/Restaurant/ Institutional Education (CHRIE)
Laura Pfalzer
Project Director
1200 17th Street, NW - 7th Floor
Washington, DC 20036-3097
Tel: (202) 331-5990
Fax: (202) 785-2511
E-mail: alliance@access.digex.net

HUMAN SERVICES

Human Services Research Institute (HSR1)
Marianne Taylor
Project Director
2336 Massachusetts Avenue
Cambridge, MA 02140
Tel: (617) 876-0426
Fax: (617) 492-7401
E-mail: marianne@hsri.org

INDUSTRIAL LAUNDRY

Uniform and Textile Service Association (UTSA)
David Dunlap
Director of Environmental and Regulatory Affairs
1300 North 17th Street, Suite 750
Rosslyn, VA 22209
Tel: (703) 247-2608
Fax: (703) 841-4750

METALWORKING

National Institute for Metal Working Skills (NIMS)
Robert Sherman
Project Director
2209 Hunter Mill Road
Vienna, VA 22181
Tel: (703) 255-5886
Fax: (703) 938-4342
E-mail: rws100.aol.com

PHOTONICS

Center for Occupational Research and Development (CORD) - Photonics Project
Darrell Hull
Project Director
601 Lake Air Drive
Waco, TX 76710
Tel: (817) 772-8756 or (800) 972-2766
Fax: (817) 772-8972 l
E-mail: dhull@cord.org

PRINTING

Graphic Arts Technical Foundation (GAFT)
Jack Simich Project Director
4615 Forbes Avenue
Pittsburgh, PA 15213-3796
Tel: (412) 621-6941
Fax: (412) 621-3049

RETAIL TRADE

National Retail Institute
Kathryn J. Mannes
Education Coordinator
325 - 7th Street, NW
Suite 1000, Liberty Place
Washington, DC 20004
Tel: (202) 783-7971 or (202) 626-8110
Fax: (202) 737-2849

WELDING

American Welding Society (AWS)
Nelson Wall
Deputy Executive Director
550 Northwest LeJeune Road
Miami, FL 33126
Tel: (305) 443-9353
Fax: (305) 443-7559

OCCUPATIONAL SKILL STANDARDS PROJECTS

Funded by the National Skill Standards Board

Background: The National Skill Standards Board (NSSB) solicited proposals from the 22 skill standards pilot projects funded by the U.S. Departments of Labor and Education to pilot components of a national voluntary skill standards system. The eight approved projects are listed below.

American Chemical Society (ACS)
Kenneth Chapman
Head of Technicians Resources/Education
1155 16th Street, NW
Washington, DC 20036
Tel: (202) 872-8734
Fax: (202) 872-8068
E-mail: kmc97@acs.org

American Electronics Association (AEA)
Cheryl Fields Tyler
Vice President, Workforce Policy & Program
5201 Great America Parkway
P.O. Box 54990
Santa Clara, CA 95056
Tel: (800) 284-4232
Fax: (408) 970-8565
E-mail: cheryl_fields_tyler@aeanet.org

Center for Occupational Research and Development (CORD) - Photonics Project
Darrell Hull
Project Director
601 Lake Air Drive
Waco, TX 76710
Tel: (817) 772-8756 or (800) 972-2766
Fax: (817) 772-8972 l
E-mail: dhull@cord.org

Council on Hotel/Restaurant/ Institutional Education (CHRIE)
Laura Pfalzer
Project Director
1200 17th Street, NW - 7th Floor
Washington, DC 20036-3097
Tel: (202) 331-5990
Fax: (202) 785-2511
E-mail: alliance@access.digex.net

Education Development Center (EDC)
Judith Leff
Senior Project Director
55 Chapel Street
Newton, MA 02158
Tel: (617) 969-7100
Fax: (617) 332-4318
E-mail: judyl@edc.org

Far West Laboratory for Educational Research and Development (FWL)
Vince Constabileo
730 Harrison Street
San Francisco, CA 94107-1242
Tel: (415) 241-2712
Fax: (415) 241-2702

Human Services Research Institute (HSRI)
Marianne Taylor
Project Director
2336 Massachusetts Avenue
Cambridge, MA 02140
Tel: (617) 876-0426
Fax: (617) 492-7401
E-mail: marianne@hsri.org

Laborers-AGC Education and Training Fund
John Tippie
Associate Director for Western U.S. & Canada
27055 Ohio Avenue
P.O. Box 419
Kingston, WA 98356
Tel: (360) 297-4152
Fax: (360) 297-3368
E-mail: 71112.1275@compuserve.com

Educational Resources Information Center (ERIC)

SCIENCE, MATHEMATICS, ENGINEERING AND TECHNOLOGY RESOURCES

Allen, R. D. (1994, December/January). Community Colleges—Answering the Needs of Science Education. *Journal of College Science Teaching, 22* (n3), 158–59.

Anderson, B. J. (1993, Spring). Strategies for Making Mathematics Work for Minorities. *AMATYC Review, 14* (n2), 5–9.

Anderson, D. (1992, Winter). Building a College That Builds Science: New Programs at Lac Courte Oreilles Ojibwa Community College Stress Science and Technology. *Tribal College: Journal of American Indian Higher Education, 3* (n3), 22–23.

Anderson, L. D. (1992, November). *Relationship of Technology Education to Tech Prep.* Paper presented at the Mississippi Valley Industrial Teacher Education Annual Conference, Chicago, IL.

Baldwin, A. (1993, February). *Indicators of Success for University Transfer of Miami-Dade Community College Graduates in Business/Management, Computer Science, and Engineering.* (Report No. 93-03R). FL: Miami-Dade Community College Office of Institutional Research. (ERIC Document Reproduction Service No. ED 366395 JC940118).

Biermann, C. A.; Sarinsky, G. B. (1993, Winter). Hands-on versus Remediation: Alternative Strategies for a Community College Biology Preparatory Course. *Community College Review, 21* (n3), 53–61.

Birley, G. (1995, June). A Case-Study of the Decision-Making Processes in One City Technology College. *School Organisation, 15* (n2) 155–61.

Bolge, R. D. (1995, March). Examination of Student Learning as a Function of Instructor Status (Full-Time versus Part-Time) at Mercer County Community College. Trenton, NJ: Mercer County Community College.

Bowen, R. C. (1992, April). *Infusing Technology into Education.* Paper presented at the New Horizons Conference for the Virginia Community College System, Richmond, VA.

Bragg, D. D. (1994, June). Emerging Tech Prep Models: Promising Approaches to Educational Reform. *Centerfocus,* (n4), National Center for Research in Vocational Education, Berkeley, CA. Sponsoring Agency: Office of Vocational and Adult Education (ED), Washington, DC.

Brown, J. A. (1992, August). *Tech Prep II: Implementation Final Report.* Danville Area Community Coll., IL. Sponsoring Agency: Illinois State Board of Education, Springfield. Dept. of Adult, Vocational and Technical Education.

Burton, L.; Celebuski, C. A. (1995, March). *Technical Education in 2-Year Colleges.* (HES Survey Number 17). National Science Foundation, Washington, D.C., Div. of Science Resources. Sponsoring Agency: Department of Education, Washington, DC.; National Endowment for the Humanities (NFAH), Washington, DC.

Caprio, M. W. (1993, February). Teaching Seems More Complicated than I First Thought. *Journal of College Science Teaching, 22* (n4), 218–20.

Caprio, M. W. (1993, March/April). Cooperative Learning—The Jewel among Motivational Teaching Techniques. *Journal of College Science Teaching, 22* (n5) 279–81.

Caprio, M. W. (1994, December/January). The SCST Position Paper. *Journal of College Science Teaching, 23* (n3), 143–44.

Claire, S. (1992). *How To Start a MESA Center at a Community College.* Aptos, CA: Cabrillo College.

Colelli, L. A. (1993). *Tech Prep & Technology Education: A Positive Focus for Competitive Literacy.* International Technology Education Association, Reston, VA.

Cottle, P. D.; et al. (1994, September). Community-College Graduates in College Physics at a University. *Physics Teacher, 32* (n6), 382–83.

Cunningham, P. (1995, June). *A Survey of Computer Use in Associate Degree Programs in Engineering Technology.* Ed.D. Practicum, Nova Southeastern University.

Davis, S. A.; Jerome, D. (1992, Winter). Turtle Mountain's College for Kids: The Turtle Mountain Reservation Becomes a Living Laboratory for Indian Students. *Tribal College: Journal of American Indian Higher Education, 3* (n3), 14–15.

Dickinson, P. R. (1992). Partnership for Environmental Technology Education. (Discussion Paper No. 106). International Labour Office, Geneva (Switzerland).

Farmer, M. H. (1993, May). Preparedness Assessment of First-Year Physical Science Students in a Two-Year College. *Journal of College Science Teaching, 22* (n6), 346–50.

Farynaiarz, J. V.; Lockwood, L. G. (1992, May). Effectiveness of Microcomputer Simulations in Stimulating Environmental Problem Solving by Community College Students. *Journal of Research in Science Teaching, 29* (n5), 453–70.

Field, David; et al. (1992, August). Transitions. *Tech Directions, 52* (n1) 11–20.

Foley, G. D.; et al. (1993, Fall). Guidelines for the Academic Preparation of Mathematics Faculty at Two-Year Colleges. *AMATYC Review, 15* (n1), 40–49. Qualifications Subcommittee, a Subcommittee of the Education Committee of the American Mathematical Association of Two-Year Colleges (Preparer).

Green, J. E.; Weaver, R. A. (1994). *Tech Prep: A Strategy for School Reform. Fastback 363.* Phi Delta Kappa Educational Foundation, Bloomington, IN.

Grinnell, Eleanor; Sherman, Janet. (1992, December). *Ambassadors in Industry: Integrating the Curriculum.* Paper presented at the American Vocational Association Convention (St. Louis, Missouri). Laramie County School District 1, Cheyenne, WY.

Groff, W. (1994, Winter). *Toward the 21st Century: Preparing Proactive Visionary Transformational Leaders for Building Learning Communities.* Human Resource Development. Tampa Cluster.

Harmon, H. L. (1992, August). *Work Force Preparation for Technician-Level Occupations.* Summary of a presentation made at the Technical and Adult Education Conference (17th, Charleston, WV).

Hatton, M. J., Comp. (1995). *Exemplary Training Models in Industrial Technology.* Association of Canadian Community Colleges. Canadian International Development Agency, Ottawa, Ontario (Sponser).

Hershey, A.; et al. (1995). *The Diverse Forms of Tech-Prep: Implementation Approaches in Ten Local Consortia.* Mathematical Policy Research, Princeton, N.J. Sponsoring Agency: Department of Education, Washington, DC, Office of the Under Secretary.

Hill, Susan T.; et al. (1992, December). *Undergraduate Origins of Recent Science and Engineering Doctorate Recipients.* National Science Foundation. Div. of Information Science and Technology. Washington, DC.

Holcomb, J. David; et al. (1994, December/January). Faculty Enhancement at Two-Year Colleges: A Partnership Approach. *Journal of College Science Teaching, 22* (n3), 187–91.

Jacobs, J. (1993, September). Vocational and General Education: New Relationship or Shotgun Marriage? *Leadership Abstracts,* v6 (n9), League for Innovation in the Community College. Sponsoring Agency: Kellogg Foundation, Battle Creek, MI.

Kangas, J. (Fall 1988–Spring 1992). *San Jose City College: Persistence of New College Students from Arithmetic, Algebra, and Int Algebra through Transfer Level Math.* (Research Reports #260, #295, and #297). San Jose, CA: San Jose/Evergreen Community College District.

Kangas, J. (Fall 1988-Spring 1992). *Evergreen Valley College: Persistence of New College Students from Arithmetic, Algebra and Int Algebra through Transfer Level Math,* (Research Reports #261, #294, and #296). San Jose, CA: San Jose/Evergreen Community College District.

Keyser, J. O. (1993,September/October). The Science Learning Center at Maryland's Montgomery College. *Journal of College Science Teaching, 23* (n1), 25–28.

Kish, E. R.; Santa Rita, E. (1992). *The Minority Honors Program in Energy-Related Curricula.* New York: Bronx Community College.

Kysilka, M.; Zapico, S. (1992, May). *The Quasi-Mastery Learning Instructional System for Community College Chemistry.* Paper presented at the Annual International Conference of the National Institute for Staff and Organizational Development on Teaching Excellence and Conference of Administrators (14th, Austin, TX, May 24–27).

Lawson, A. E.; et al. (1993, November). The Role of Hypothetico-Deductive Reasoning and Physical Analogues of Molecular Interactions in Conceptual Change. *Journal of Research in Science Teaching, 30* (n9), 1073–85.

McCarty, S.; et al. (1994). *Health Science Technology Education (HSTE: A Working Model.* Texas University, Austin. Extension Instruction and Materials Center. Sponsoring Agency: Texas Education Agency, Austin.

Mortimore, J.; Mortimore, P. (1995, June). Innovatory Staffing Practices in City Technology Colleges. *School Organisation, 15* (n2), 145–53.

Murphy, P. (1993, Winter). Educational Revolution on the Reservation: A Working Model. *Winds of Change, 8* (n1), 12–19.

Najee-ullah, D.; et al. (1993, December). *Minorities in Mathematics: Georgia State University Atlanta Metropolitan College Partnership Project.* Final Report. Georgia State University, Atlanta. Center for the Study of Adult Literacy. Funding also provided by the GTE Focus Program. Sponsoring Agency: American Council on Education, Washington, DC. National Center for Academic Achievement and Transfer; Ford Foundation, New York, NY.

Owens, T. R. (1995, March). *The Boeing Company's Manufacturing Technology Student Internship.* Evaluation Report. Northwest Regional Educational Lab., Portland, OR.

Packer, A. H. (1994, November). *An Associate Degree in High-Performance Manufacturing.* Final Report. Pennsylvania Association of Developmental Educators. Work was done under a grant from the Sloan Foundation.

Pantano, J. (1994, May). *Comprehensive Minority SEM Programs at Santa Fe Community College.* Paper presented at the Annual International Conference of the National Institute for Staff and Organizational Development on Teaching Excellence and Conference of Administrators (Austin, TX, 1994).

Petrowsky, M. (1994, June). *Math Background as a Predictor of Student Success in the College Economic Principles Courses: A Preliminary Analysis.* AZ: Glendale Community College.

Rhoton, J. (1993, March/April). The Critical Role of Two-Year Colleges in Improving Science, Mathematics, and Engineering Education. *Journal of College Science Teaching, 22* (n5), 268–69.

Roberts, P. B. (1994, December). *Integrating Technology Education and Tech Prep.* Paper presented at the American Vocational Association Convention.

Sackett, J. (1994). *The State of Basic Math at T-VI: A Report from the Faculty.* Albuquerque Technical Vocational Institute, NM. Project supported by funds from the Carl D. Perkins Vocational Expansion Program.

Schwartz, R. (1992, Fall–Spring). Mathematics and Demography. *Community Review, 12* (n1-2), 36–40.

Seese, L. (1994, February). *Revising the Mathematics Department.* Paper presented at the International Conference for Community College Chairs and Deans (3rd, Phoenix, AZ, February 23–26).

Soetaert, E. (1993, June). *Student Success Programs at the Northern Alberta Institute of Technology.* Paper presented at the Annual Conference of the Association of Canadian Community Colleges (Edmonton, Alberta, Canada).

Stephenson, G. W. (1995, April). *The American Community College: Essential to the American Dream.* Paper presented at the Annual Convention of the American Association of Community Colleges (75th, Minneapolis, MN, April 22–24, 1994).

Stout, D. L. (1993, November). Collaboration between Professional Societies and Two-Year Schools. *Journal of College Science Teaching, 23* (n2), 74–75.

Turlington, A. J. (1994, July). *Integrating the Curriculum.* PACE "How To" Handbooks for Tech Prep. Partnership for Academic and Career Education, Pendleton, SC. Sponsoring Agency: Department of Education, Washington, DC.

Turlington, A. J. (1994, September). *The PACE Guide to Area Business Speakers.* PACE "How To" Handbooks for Tech Prep. Partnership for Academic and Career Education, Pendleton, SC. Sponsoring Agency: Department of Education, Washington, DC.

Turlington, A. J. (1994, October). *The Tech Prep News.* PACE "How To" Handbooks for Tech Prep. Partnership for Academic and Career Education, Pendleton, SC. Sponsoring Agency: Department of Education, Washington, DC.

Uretsky, Jack L. (1993, November). Using "Dialogue" Labs in a Community-College Physics Course. *Physics Teacher, 31* (n8), 478–81.

Vejdani-Jahromi, M.; et al. (1994, Fall). A New Approach in Teaching Developmental Mathematics. *Research and Teaching in Developmental Education, 11* (n1), 85–95.

Walter, D. M. (1992). *Developing "Real World" Applications for Academic Concepts . . . A Teacher's Guide.* Partnership for Academic and Career Education, Pendleton, SC.

Walter, D. M. (1995, June). *Integrating Work-Based Learning into Comprehensive Tech Prep Programs: Recommendations from a Practitioner's Perspective.* Partnership for Academic and Career Education, Pendleton, SC.

Walter, D. M., Comp. (1993, November). *Tech Prep and Dropout Prevention.* Revised. Partnership for Academic and Career Education, Pendleton, SC.

Wang, W. (1994, October). Teaching College Physics in China and in America. *Physics Teacher, 32,* (n7), 437–39.

Watkins, Ann; et al. (1993, Spring). A Survey of Two-Year College Mathematics Programs: The Boom Continues. *AMATYC Review, 14* (n2), p55–66.

Wheatley, J. H.; Tew, W. R. (1993, November/December). The Value Placed on Secondary School Experience by Science Instructors and Personnel Officers at Community Colleges. *American Biology Teacher, 55* (n8), 473–75.

Williams, L. S. (1992, October). *Partners in Changing Math & Science Education: The Role of the National Science Foundation, the Role of Community Colleges.* Paper presented at the Annual Computer Conference of the League for Innovation in the Community College (9th, Orlando, FL, October 21–24, 1992).

Ziegler, J.; Taylor, D. (1992). *Improving Math Literacy for the Facilities Maintenance Industry: A Multimedia Approach.* Waco, TX: Texas State Technical College.

Educational Resources Information Center (ERIC)

ACADEMIC STANDARD RESOURCES

Abraham, A. (1986). College-Level Study: What Is It? Variations in College Placement Tests and Standards in the SREB States. *Issues in Higher Education*, Number 22. Southern Regional Education Board, Atlanta, GA. 7p. ED277715 TM860655.

Akst, G. (1984). *Reflections on Basic Math Programs in the Two-Year College.* Paper presented at the Sloan Foundation Conference on New Directions in Two-Year College Mathematics (Atherton, CA, July 11–14, 1984). ED246925 JC840305.

Akst, G.; Hirsch, L. (1991). Selected Studies on Math Placement. Appalachian State University, Boone, NC. Center for Developmental Education. *Review of Research in Developmental Education, 8* (n4), 6. ED354964 JC930136.

American Association for the Advancement of Science, Washington, DC; Association of American Colleges, Washington, DC. (1982, June). *Science and Technology Education for Civic and Professional Life: The Undergraduate Years.* A Report of the Wingspread Conference (Racine, WI, June 1–3, 1982). 37p. ED231288 HE016275.

Bahmueller, C. F. (1995, April). *National Standards for Civics and Government.* ERIC Digest. ERIC Clearinghouse for Social Studies/Social Science Education, Bloomington, IN. ED380401 SO024872.

Bailey, T.; Merritt, D. (1995, December). *Making Sense of Industry-Based Skill Standards.* National Center for Research in Vocational Education, Berkeley, CA. ED389897 CEO70410.

Barker, F. M.; Suchoff, I. B. (1995, Winter). The 1994 Revised COE Accreditation Standards. *Optometric Education, 20* (2), 44–45. EJ497794 HE533485.

Barrett, M. J.; et al. (1993, June). *Standard-Setting Study of College Board Mathematics Level I and Mathematics Level II Achievement Tests for Use in Course Placement and*

Credit by Examination in Mathematics 305G at the University of Texas at Austin—Fall 1991. University of Texas, Austin. Measurement and Evaluation Center. ED362554 TM020594.

Battistini, J. (1995). *From Theory to Practice: Classroom Application of Outcome-Based Education.* ERIC Clearinghouse on Reading, English, and Communication, Bloomington, IN. 4p. ED377512 CS214679.

Boese, L.; Birdsall, L. (1993, March). *Instructor Grading Variation and Its Implications for Asessment, Advising and Academic Standards.* Paper presented at the Annual Research Conference of the Research and Planning Group for California Community Colleges (Lake Tahoe, CA, March 3–5). ED365371 JC940035.

Botstein, L. (1983, June). Nine Proposals to Improve Our Schools. *New York Times Magazine,* 58–67. EJ282305 UD509963.

Bottoms, G. (1992, November/December). Closing the Gap. *Vocational Education Journal, 67* (n8), 26–27. EJ452466 CE524253.

Brook, N.; Parry, A. (1985, Summer). The Influence of Higher Education on the Assessment of Students of Physiotherapy. *Assessment and Evaluation in Higher Education, 10* (n2), EJ323981 HE519901.

Broughman, S.; Rohr, C. L. (1995, January). *Private School Graduation Requirements.* Issue Brief. National Center for Education Statistics (USED), Washington, DC. ED381870 EA026655.

California Community Colleges. (1989, October). *Statement on Competencies in Mathematics Expected of Entering Freshmen.* California State University, Sacramento. Academic Senate. ED324242 SE051633.

Carmichael, J. W. (1982, December). Standards with Sympathy. *New Directions for Testing and Measurement, (Academic Testing and the Consumer),* (n16), 39–44. EJ277443 TM507790.

Coffey, J. C. (1983, April). *Remedial Education in California's Public Colleges and Universities: Campus Perspectives on a Serious Problem.* California State Postsecondary Education Commission, Sacramento. 13p. ED230227 JC830220.

Cohen, D. (1993). *Standards for Curriculum and Pedagogical Reform in Two-Year College and Lower Division Mathematics.* Circulating Draft. American Mathematical Association of Two-Year Colleges. Prepared by the Curriculum and Pedagogical Reform in Two-Year Colleges and Lower Division Mathematics Task Force. ED362248 JC930475.

Cohen, D. (1995, September). *Crossroads in Mathematics: Standards for Introductory College Mathematics before Calculus.* American Mathematical Association of Two-Year Colleges. Prepared by the Writing Team and Task Force of the Standards for Introductory College Mathematics Project. ED386231 JC950420.

Coleman, D. R.; Bolte, J. R. (1988, May). *Curricular Impact of College Level Skills Assessments.* AIR 1988 Annual Forum Paper. 21p.; Paper presented at the Annual Forum of the Association for Institutional Research (28th, Phoenix, AZ, May 15–18, 1988). ED298862 HE021853.

Cross, L. H.; et al. (1003). College Grading: Achievement, Attitudes, and Effort. *College Teaching, 41* (n4), 143–48. EJ477870 HE532248.

DeStefano, L. (1993, October). *The Effects of Standards and Assessment on Students in Special Education.* Synthesis Report 10. Minnesota University, Minneapolis College of Education. ED366167 EC302771.

Dey, E. L.; et al. (1995, May). *Does Being Student-Centered Lead to Lower Academic Standards?* Paper presented at the Annual Forum of the Association for Institutional Research (35th, Boston, MA, May 28–31, 1995). ED387013 HE028594.

Dinham, S. M. (1989). *Assessment, Accreditation, and Licensure, and Their Effects upon Teaching and Learning.* Arizona University, Tucson. Center for Research on Undergraduate Education. 10p.; Paper prepared for presentation at the Annual Meeting of the American Evaluation Association (San Francisco, CA, 1989). ED313374 SP031784.

Donmoyer, R. (1995, Winter). Rhetoric and Reality of Systemic Reform: A Critique of the Proposed National Science Education Standards. *Cognosos, 4* (n1), 1–3, 7–8. ED380302 SE055990.

Dunkle, S. E. (1984, December). *Use of Mastery Learning Approach in Allied Health Programs: Emergence of Higher Education.* 40p.; Doctoral Practicum Paper, Nova University. ED260606 HE018554.

Nevada University System, Reno. (1985, January). *Future Directions for Nevada's Colleges and Universities.* University of Nevada System Planning Report: 1985–1989. 78p. ED256240 HE018275.

Elam, S. M.; Rose, L. C. (1995, September). The Phi Delta Kappan/Gallup Poll of the Public Attitudes Toward the Public Schools. *Phi Delta Kappan, 77* (n1), 41–56. EJ511697 EA531010.

Flanagan, P. A. (1992, December). *Raising Standards: State Policies To Improve Academic Preparation for College.* Westat, Incorporated, Rockville, MD. 229p. ED356736 HE026392.

Fleischman, H. L.; and others. (1995, August). *State Certification Requirements for Teachers of Limited Proficient Students in State Performance Standards and Assessments.* Annual Report: Year Three. Volume VII: Task D160 Report. Special Issues Analysis Center (SIAC). ED389183 FLO23364.

Fletcher, D. Q. (May/June, 1990). Does ABET Live Up to Its Acronym? *Engineering Education, 80,* (n4), 450–53. EJ412349 SE546472.

Florida State Department of Education, Tallahassee. (1986). *Student Achievement of College-Level Communication and Computation Skills in Florida: 1985–86.* 47p.; Paper prepared as part of the American Association for Higher Education Assessment Forum. ED295504 HE020439.

Gandal, M. (1995, September). Why We Need "Academic" Standards. *Educational Leadership, 53* (n1), 84–86. EJ511734 EA531065.

Geenen, K.; et al. (1993, September). *Synthesis Report Update 1993: Recent Activities in National Goals, Standards and Tests.* Synthesis Report 8. Minnesota University, Minneapolis College of Education. 71p. ED366165 EC302769.

Geenen, K.; et al. (1995, February). *Synthesis Report Update 1994: Reports on the Status of Education, Desired Outcomes, and Reform Initiatives.* Synthesis Report 16. National Center on Educational Outcomes, Minneapolis, NM. ED385060 EC304093.

General Accounting Office, Washington, DC. National Security and International Affairs Division. (1991, July). *Naval Academy: Low Grades in Electrical Engineering Courses Surface Broader Issues.* Report to Congressional Requesters. ED337074 HE024885.

Greenwood, A. (1993, May). National Assessment of College Student Learning: Getting Started. A Summary of the Beginning Activities. National Center for Education Statistics, Washington, DC. 192p. ED359856 HE026489.

Hector, J. (1993, November). *Curriculum and Pedagogical Reform for Lower-Division Mathematics: Moving beyond Myths to Standards.* Paper presented at "Reinventing the Community College," the Annual Computer Conference of the League for Innovation in the Community College (10th, Nashville, TN, November 14–17, 1993). ED366384 JC940104.

Henderson, R. P. (1983, November). Meeting the Needs for a High-Technology America. *USA Today, 112* (n2462), 47–49. EJ288924 SO511900.

Hoge, J. D. (1994, September). Achieving History Standards in Elementary Schools. ERIC Digest. ERIC Clearinghouse for Social Studies/Social Science Education, Bloomington, IN. ED373020 SO024558.

Houghton, J. R. (1996, July). Why Do We Need National Skill Standards? *NSSB WorkWise,* v1, (1), 1–2.

Hunt, E. S. (1993, October). *A Guide to the International Interpretation of U.S. Education Program Data: CIP, IPEDS, CCD and ISCED.* National Center for Education Statistics. ED364588 TM020815.

Ishler, P. F.; Selke, M. J. (1994, February). *A Study of Involvment of NCATE Institutions in the Support of Beginning Teachers.* Paper presented at the National Meeting of the Association of Teacher Educators (Atlanta, GA, February 1994). ED378178 SP035697.

Kane, M. (1993, June). *The Validity of Performance Standards.* National Assessment Governing Board, Washington, DC. ED365689 TM020835.

Lachat, M. A. (1994, May). *Learner-Based Accountability: Making Schools Work for All Students.* Trinity College, Burlington, VT. 53p. ED383160 EC303994.

Loeb, J. W. (1992). *Academic Standards in Higher Education.* Selective Admission Series. College Board, New York, NY. 86p. ED350900 HE025876.

Lopez, G. A. (1990, March). *Improvement for Undergraduate Education in Texas: College-Level Competencies.* Texas Higher Education Coordinating Board, Austin. 22p. ED332650 HE024630.

Markham, K. (1993, May). *Standards for Performance.* ERIC Digest, No. 81. ERIC Clearinghouse on Educational Management, Eugene, OR. ED356553 EA024814.

McCurdy, D. W. (1983, November). National and Legislative View: The Relevance of the Report of the Commission on Excellence in Education to College Science Teachers. *Journal of College Science Teaching, 13* (n2), 108–09. EJ288623 SE534413.

McNeir, G. (1993, October). *Outcome-Based Education.* ERIC Digest, No. 85. ERIC Clearinghouse on Educational Management, Eugene, OR. ED363914 EA025282.

Miller, S.; McDermott, P. (1983, Fall). A Workshop that Works: Math Remediation. *Improving College and University Teaching, 31* (n4), 172–75. EJ291816 HE517627.

Minnesota Higher Education Coordinating Board, St. Paul. (1986, January). *Defining College-Level Skills.* Report of the Task Force on Definition of College-Level Skills. 86p. ED278303 HE019970

Moore, K. D. (1993). NCATE Accreditation: Visions of Excellence. *Journal of Research and Development in Education, 27* (n1), 28–34. EJ478567 SP522939.

Moore, K. D.; et al. (1994, Spring). NCATE Standards: Restructuring Teacher Education. *Teacher Education Quarterly, 21* (n2), 27–36. EJ488796 SP523432.

Morton, S.; et al. (1993, November). *Academic Standards for Interscholastic Athletic Participation.* North Carolina University, Chapel Hill. School of Education. November 1993. 24p. ED375116 SP035493.

National Alliance of Business, Washington, DC. *Standards Mean Business.* 1996. 24p.

National Association of State Directors of Special Education, Alexandria, VA. *Summary of Goals 2000: Educate America Act.* (1994, September). New Mexico University, Albuquerque. ED389130 EC304416.

National Center of Educational Outcomes, Minneapolis, MN. (1995). *Foundations for NCEO's Outcomes & Indicators Series.* 7p. ED391321 EC304570.

National Commission on Excellence in Education (ED), Washington, DC. (1982, October). *Public Hearing on Preparation for the Transition to Higher Education.* (Chicago, IL, October 6, 1982). ED244540 HE017243.

National Education Goals Panel, Washington, DC. (1995, July). *Inventory of Academic Standards-Related Activities.* Report No. 95-07. ED389085 EA027199.

Nerad, M. (1986, February). *Achievement in Five Industrialized Countries: What Can We Learn from the Comparison?* University Admission Requirements and Secondary School Graduation. Paper presented at the Annual Meeting of the American Educational Research Association (67th, San Francisco, CA, April 16–20, 1986). ED276353 HE019850.

New Mexico Commission on Higher Education. (1987, April). *Academic Preparation for College: A Joint Project.* Final Report. New Mexico State Department of Education, Santa Fe. 43p. ED285457 HE020581.

Newman, R. E.; Miller, M. T. (1995). *Attitudes of High School Personnel Toward NCAA Academic Integrity Reform Measures and Proposals.* ED386108 HE028516.

Noreen, R. (1987, October). *Conference on English and Mathematics.* Proceedings (October 21–23, 1987, Napa, CA). California Community Colleges, Sacramento. California State University and Colleges, Long Beach. Office of the Chancellor. 67p. ED294615 JC880217.

Paul, R.; Nosich, G. M. (1992). *A Model for the National Assessment of Higher Order Thinking.* ED353296 TM019311.

Piland, W. E.; Villanueva, X. (1993, March/April). Academic Standards in the California Community Colleges: A Study of Faculty Perceptions. *Community College Journal of Research and Practice, 17* (n2), 173–86. EJ461679 JC506329.

Ravitch, D. (1992, August). *Developing National Standards in Education.* U.S. Office of Educational Research and Improvement. Paper Presented at the Annual Meeting of the American Sociological Association. ED351350 TM019158.

Rees, J. M.; et al. (1992, Winter). Addressing Professional Standards for the Preparation of Mathematics Teachers. *STRATE Journal, 1* (n1), 43–46. EJ449404 SP521469.

Resnick, L. B.; Resnick, D. (1992, February). *Report on New Standards Tasks and Protocols for Piloting.* Project 2.1: Approaches to Assessment in Mathematical Problem Solving. Center for Research on Evaluation, Standards, and Student Testing, Los Angeles, CA. ED348380 TM018747.

Sandrock, P. (1995, Spring). Competency-Based Admission: A project of the University of Wisconsin System. *ADFL Bulletin, 26* (n3), 55–57. EJ505107 FL524715.

Saunders, J. C.; Linton, D. L. (1985, Fall). The Effect of Examinee Pass/Fail Information on the Level of Passing Score Set by Expert Judges. *Florida Journal of Educational Research, 27* (n1), 5–18. ED323225 TM015428.

Seese, L. (1994, February). *Revising the Mathematics Department.* Paper presented at the International Conference for Community College Chairs and Deans (3rd, Phoenix, AZ, February 23–26, 1994). ED367422 JC940193.

Sheffield, L. J. (1994, June). *The Development of Gifted and Talented Mathematics Students and the National Council of Teachers of Mathematics Standards.* Mathematics Researched-Based Decision Making Series 9404. National Center on the Gifted and Talented, Storrs, CT. ED388011 EC304366.

Shokoohi-Yekta, M.; Kavale, K. A. (1994, Fall). Effects of Increased High School Graduation Standards on College Entrance Examination Performance with Learning Disablilities. *Learning Disabilities Research and Practice, 9* (n4), 213–18. EJ494856 EC610064.

Shriner, J. G.; et al. (1993, May). *IEPs and Standards: What They Say for Students with Disabilities.* Technical Report 5. Minnesota University, Minneapolis College of Education. ED358659 EC302223.

Shriner, J. G.; et al. (1993, February). *Experts' Opinions About the Appropriateness and Feasibility of National Math Standards.* Technical Report 4. Minnesota University, Minneapolis College of Education. ED358658 EC302222.

Simon, K.; Gregg, S. (1993). *Alternative Assessment--Can Real-World Skills Be Tested?* Policy Briefs. Appalachia Educational Laboratory, Charleston, WV. 9p. ED362575 TM020649.

Southern Regional Education Board, Atlanta, GA. (1983, June). *Meeting the Need for Quality: Action in the South.* Progress Report by the Task Force on Higher Education and the Schools. 34p. ED232534 HE016430.

Stahl, F. A. (1994, Spring). A Myth Is as Good as a Mile: The Urgent Need for Literacy in Science. *College Teaching, 42* (n2), 43–46. EJ486624 HE532698.

Stewart, D. M.; Everson, H. T. (1993, March). *Toward National Standards and Testing: The Educational Equity Imperative.* Paper presented at the Ford Foundation National Symposium on Equity and Educational Testing and Assessment (Washington, DC, March 11–12, 1993). ED363617 TM020455.

Suddick, D. E.; Collins, B. A. (1986, April). *A Longitudinal Cross Validation of a Basic Skills Testing Remediation Paradigm for Older, Reentry College Juniors.* 8p.; Paper presented at the Annual Meeting of the American Educational Research Association (67th, San Francisco, CA, April 16–20, 1986). ED277331 HE019953.

Sutcliffe, W.; Pollock, J. (1992). Can the Total Quality Management Approach Used in Industry Be Transferred to Institutions of Higher Education? *Vocational Aspect of Education, 44* (n1), 11–27. EJ444026 CE523781.

The New Standard (1996, June/July). *Conference to Refocus the Standards Agenda.* Vol4, (2). Washington, DC.

Texas Higher Education Coordinating Board, Austin. (1991). *Guidelines for Fitness for Health Programs in Texas.* 41p. ED345644 HE025539

Tozer, S. (1993, Fall). Toward a New Consensus Among Social Foundations Educators: Draft Position Paper of the American Educational Studies Association Committee on Academic Standards and Accreditation. *Educational Foundations, 7* (n4), 5–22. EJ478607 SP522979.

Tucker, M. S. (1986, September/October). Better Teachers: The Arts and Sciences Connection. *Change, 18* (n5), 12–17. EJ344071 HE521430.

Steen, L. A. (1986, Summer). Stress Points in School and College Mathematics. (1986, Summer). *College Board Review,* (n140), 6–9,35–36. EJ340245 HE521174.

United States National Research Center. (1996, July). *Mathematics and Science Curriculum and Standards: An International Comparison.* The Third International Mathematics and Sciences Study. Washington, DC. 15p.

Vorp, R. (May 1987). *Correspondence between the Florida Multiple Assessment Programs and Services (MAPS) and the Scholastic Aptitude Tests (SAT) at Miami-Dade Community College Based on Students Who Wrote Both Tests.* (Research Report No. 87-21). Miami-Dade Community College, FL. Office of Institutional Research. 26p. ED305942 JC890161.

Wade, P. (1984, December). Back to Basics: Notes from Underground. *Teaching English in the Two-Year College, 11* (n2), 23–25. EJ311498 CS730636.

Warren, W. C.; Mahoney, J. R. (1984, July). *Occupational Education and Mathematics: Ownership Makes the Difference.* 14p.; Paper presented at the Sloan Foundation Conference on New Directions in Two-Year College Mathematics (Atherton, CA, July 11–14, 1984). ED248905 JC840299.

Wingo, O. G. (1993, March). The Impact of Legislated Educational Reforms on the Academic Preparation of Entering Community College Students in the State of Florida. *Community College Journal of Research and Practice, 17* (n1), 13–20. EJ458043 JC506252.

Wright, T. J.; Cistone, P. J. (1994, Fall). The Relationship between Increased Academic Standards and Student Achievment at the College Level. *Journal of Applied Research in the Community College, 2* (n2), 75–89. EJ499926 JC506932.

Ysseldyke, J. E. (1994, May). Students with Disabilities & Educational Standards: Recommendations for Policy and Practice. National Center on Educational Outcomes, Minneapolis, MN. ED372561 EC303193.

Ysseldyke, J. E.; et al. (1993, November). National Goals, National Standards, National Test: for All (Not Virtually All) Students with Disabilities? Synthesis Report 11. 12p. ED366168 EC302772.

NSF/AACC NATIONAL ROUNDTABLE ON SMET PROGRAMS IN COMMUNITY COLLEGES

Washington, D.C., June 7–9, 1996

LIST OF PARTICIPANTS

Kenneth R. Duncan
M.A.C. Planning/Future Models
U.A.W.
Saturn Corporation
100 Saturn Parkway - Mail Stop K23
Springhill, TN 37174-9998
Tel: 615/489-4014
Fax: 615/486-5294

B. Jean Floten
President
Bellevue Community College
3000 Landerholm Circle, SE
Room A201
Bellevue, WA 98007-6484
Tel: 206/641-2301
Fax: 206/641-2261
Int: bfloten@bcc.ctc.edu

Milton Goldberg
Senior Vice-President, Educational Reform
National Alliance of Business
1201 New York Avenue, Suite 700
Washington, D.C. 20005
Tel: 202/289-2944
Fax: 202/289-2908

Erik G. Halléus
Vice President & General Manager
Siemens Rolm Communications Inc.
Three Computer Drive
Mail Stop 1802 - P.O. Box 5006
Cherry Hill, NJ 08034-0365
Tel: 609/751-5080
Fax: 609/424-5689

John H. Hostetler
Principal
Walhalla High School
151 Razorback Lane
Walhalla, SC 29691
Tel: 864/638-4582
Fax: 864/638-4055

Eduardo Martí
President
Corning Community College
One Academic Drive
Corning, NY 14830
Tel: 607/962-9232
Fax: 607/962-9485
Int: President@sccvc.corning-cc.edu

Arnold Packer
Chairman, SCANS/2000
Johns Hopkins University
Institute for Policy Studies
3400 N. Charles Street
Wyman Building, 5th Floor
Baltimore, MD 21218
Tel: 410/516-4535
Fax: 410/4775
Int: packer@jhunix.hcf.jhu.edu

Robert E. Parilla
President
Montgomery College
900 Hungerford Drive
Rockville, MD 20850
Tel: 301/279-5264
Fax: 301/279-5260
Int: rparilla@mannakee.mc.mc.cc.md.us

Beverly Simone
President
Madison Area Technical College
3550 Anderson Street
Madison, WI 53704-2599
Tel: 608/246-6677
Fax: 608/246-6700
Int: bss5193@madison.tec.wi.us

Ronald J. Temple
Chancellor
City Colleges of Chicago
226 West Jackson Boulevard
Chicago, IL 60606-6998
Tel: 312/553-2510
Fax: 312/553-2699
Int: rtemple@ccc.edu

Alvin Thornton
Member, Board of Education - District 7
Sasscer Administration Building
14201 School Lane
Upper Marlboro, MD 20772
Tel: 301/952-6115
Fax: 301/952-6114
Int: ThornA@aol.com

Susie P. Walker
Administrative Assistant to the Executive Office
Litton Data Systems
6608 Sunscope Drive
Ocean Springs, MS 39564
Tel: 601/872-7525
Fax: 601/872-7325
Int: swalker@vines.dsd.litton.com

Jackie Woods
Community College Liaison
U.S. Department of Education
OVAE, Room 4090, Switzer Building
330 C Street, SW
Washington, DC 20202
Tel: 202/205-5451
Fax: 202/205-8748
Int: jacqueline_woods@ed.gov

AACC STAFF

David Pierce
President and CEO
American Association of Community Colleges
One Dupont Circle, Suite 410
Washington D.C. 20036
Tel: 202/728-0200, x235
Fax: 202/833-2467
Int: dpierce@aacc.nche.edu

James R. Mahoney
Director of Academic, Student, International Services
American Association of Community Colleges
One Dupont Circle, Suite 410
Washington D.C. 20036
Tel: 202/728-0200, x228
Fax: 202/833-2467
Int: jmahoney@aacc.nche.edu

Ada Mara Phillips
Staff Assistant for Academic, Student, International Services and Economic Development
American Association of Community Colleges
One Dupont Circle, Suite 410
Washington D.C. 20036
Tel: 202/728-0200, x256
Fax: 202/833-2467
Int: aphillips@aacc.nche.edu

NSF STAFF

Elizabeth Teles
Program Director for Mathematics
Division of Undergraduate Education
National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230
Tel: 703/306-1665, x5865
Fax: 703/306-0445
Int: eteles@nsf.gov

Bettye Lawrence
Program Consultant, Division of Undergraduate Education
National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230
Tel: 703/306-1667
Fax: 703/306-0445
Int: blawrence@nsf.gov

Gerhard Salinger
Program Director, Instructional Materials and Development Program
Division of Elementary, Secondary& Informal Education
National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230
Tel: 703/306-1614
Fax: 703/306-0445
Int: gsalinge@nsf.gov

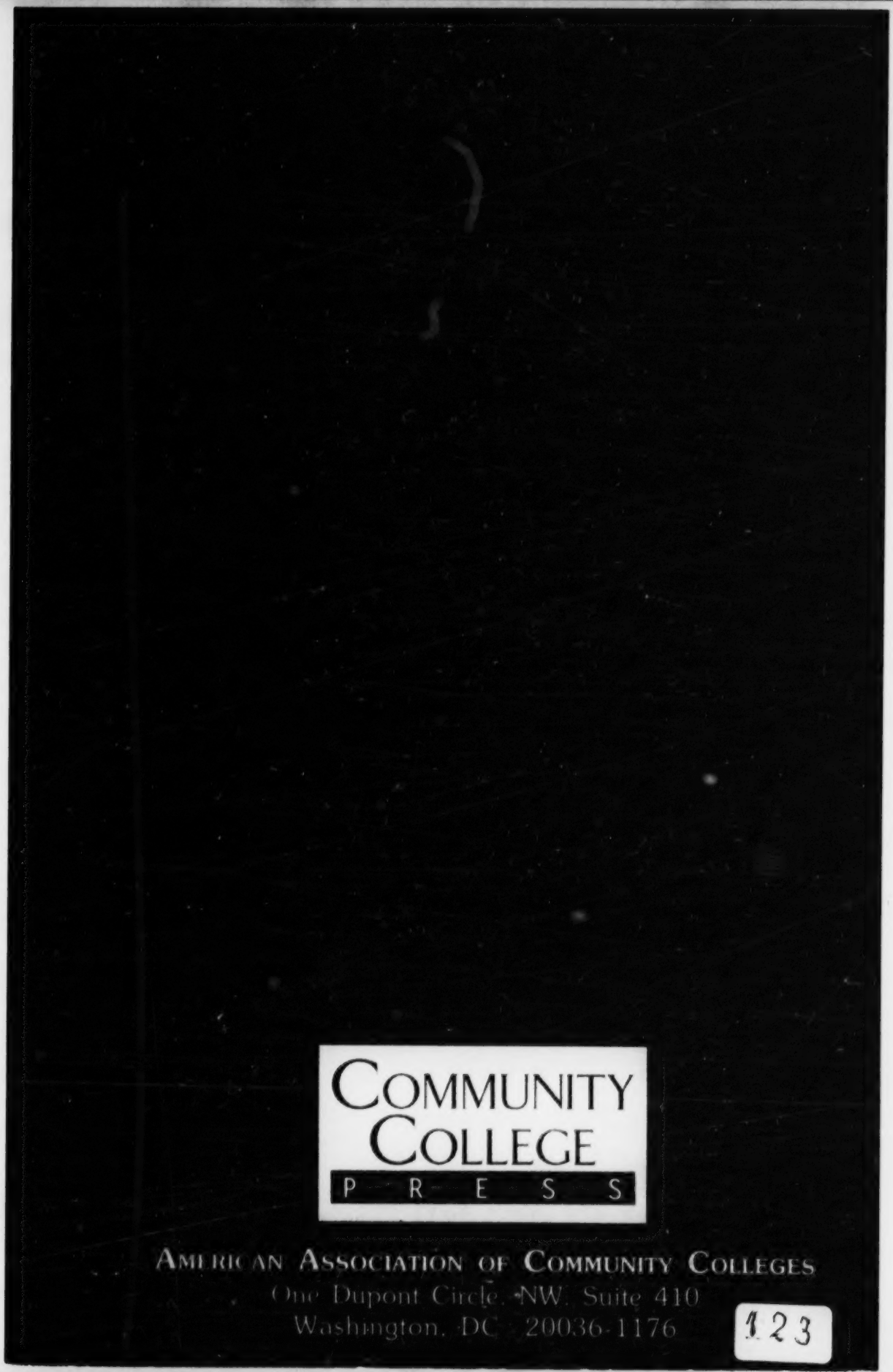
Ashok Agrawal
Program Director
National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230
Tel: 703/306-1667
Fax: 703/306-0445
Int: aagrawal@nsf.gov

GROUP SOLUTIONS, INCORPORATED

Brett Boston
President
2951 Flowers Road, South - Suite 132
Atlanta, GA 30341
Tel: 770/451-0026
Fax: 770/451-0401
Int: bostonbret@aol.com

Phil Bush
Vice President for Sales and Marketing
2951 Flowers Road, South - Suite 132
Atlanta, GA 30341
Tel: 770/451-0026
Fax: 770/451-0401
Int: bushps@aol.com

Note: Group Solutions facilitated these discussions. A major component of its management was the use of a computer-based local area network that encouraged participants to write suggestions and comments directly into a laptop computer set at each position at the table.



AMERICAN ASSOCIATION OF COMMUNITY COLLEGES
One Dupont Circle, NW, Suite 410
Washington, DC 20036-1176

123